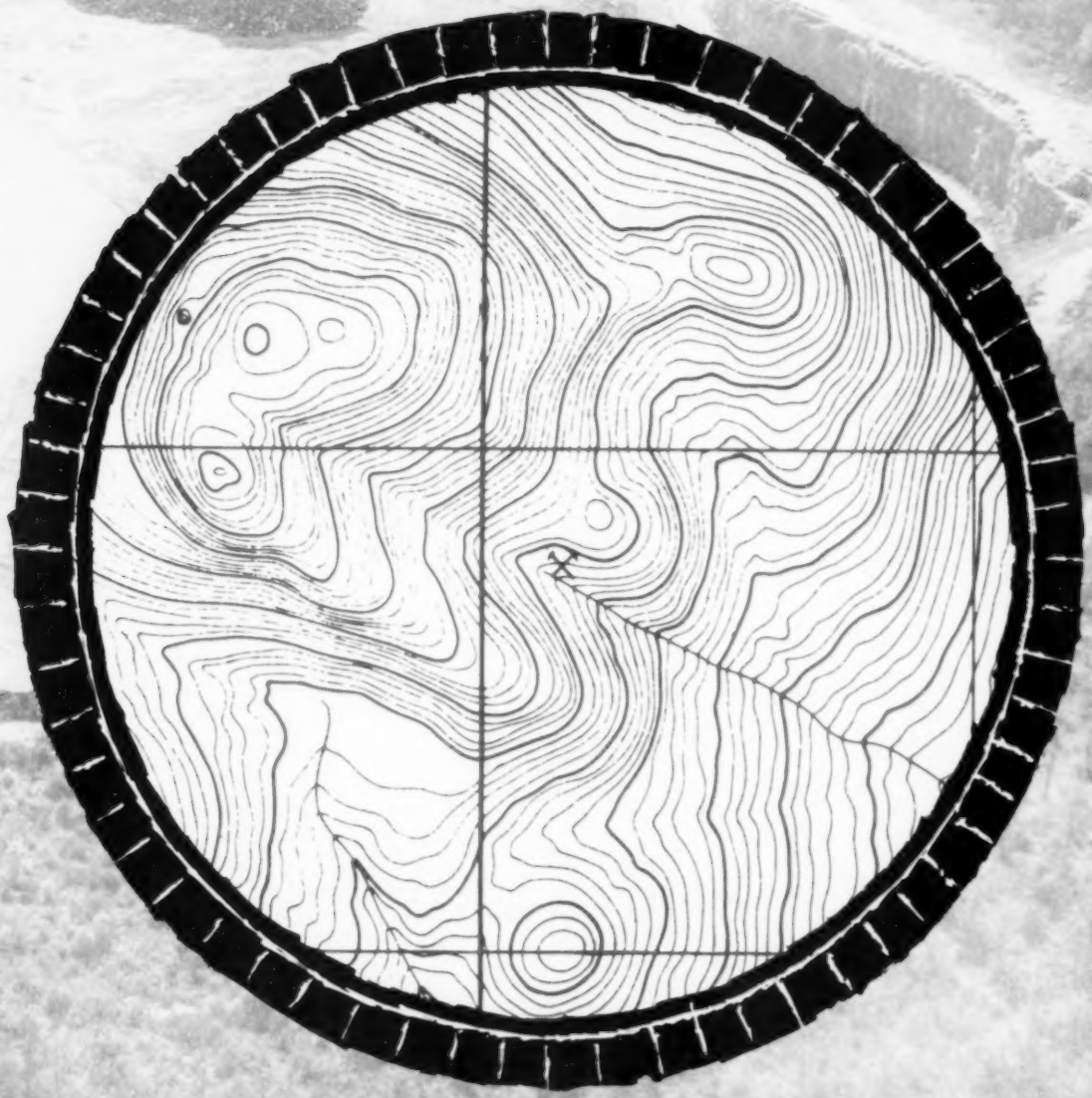
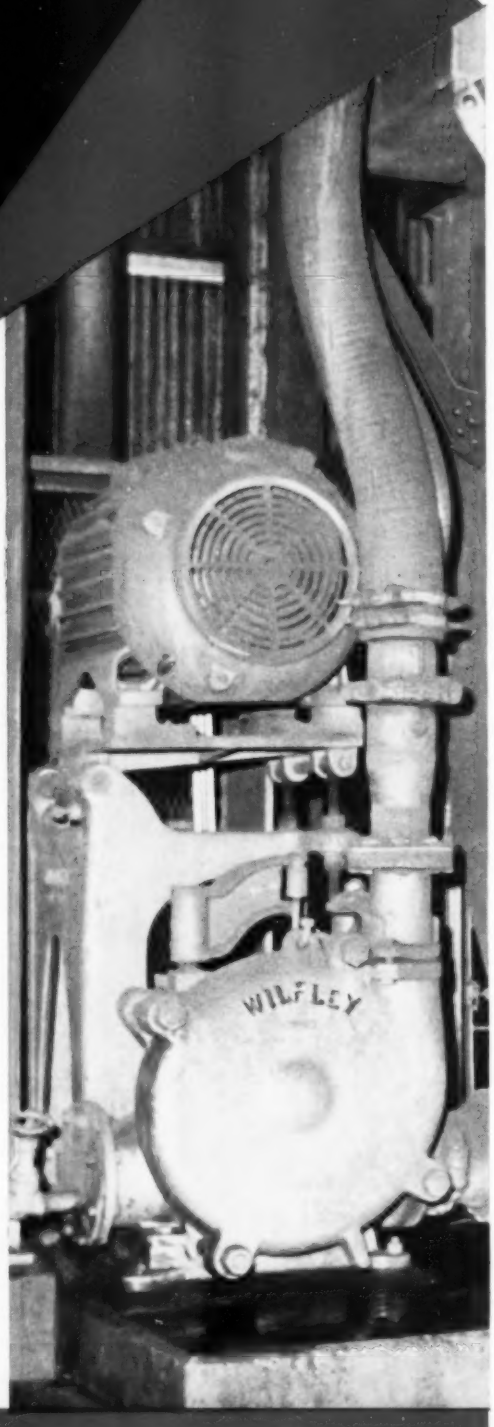
MINING engineering

MAY 1959



PHOTOGRAMMETRIC METHODS AND THE OPEN PIT MINE

HMS CYCLONES
FED BY
WILFLEY
SAND PUMPS



Steady Feed

Constant Pressure

This Heavy Media Separation job called for pumps that could provide a steady feed of pulp to a set of cyclones without loss of pressure. Wilfley got the job. The simplified design and easy take-up-adjustment of Wilfley Sand Pumps make high efficiencies possible throughout the life of the parts. Trouble-free operation, built into every Wilfley pump, means less maintenance and lower pumping costs. Even under the most severe conditions Wilfley gives you this dependable, money-saving performance. Available with long-lasting parts of hard alloy or abrasion-resistant rubber.

Individual Engineering on Every Application

Wilfley Sand Pumps
"Companions in Economical Operation"
Wilfley Acid Pumps

Write, wire or phone for complete details.

A. R. WILFLEY and SONS, INC.
DENVER, COLORADO, U.S.A., P. O. BOX 2330
NEW YORK OFFICE: 122 EAST 42ND ST., N. Y. CITY 17

COMING EVENTS

May 8-10, Fourth Annual Uranium Symposium, AIME Uranium Section, Moab, Utah.

May 11-14, American Mining Congress, Coal Show, Cleveland.

May 16, AIME Upper Peninsula Section, annual spring technical session, Michigan College of Mines and Technology, Houghton.

May 21-22, Lake Superior Mines Safety Council, 35th annual conference, Hotel Duluth, Duluth.

May 22, AIME Lehigh Valley Section, dinner-dance, Lebanon Country Club, Lebanon, Pa.

May 23, AIME Adirondack Section, field trip to Mineville, N. Y.

June, AIME Lehigh Valley Section, field trip, New Jersey Zinc Co., Friedensville, Pa.

June 8-10, Engineering Inst. of Canada, annual meeting, Toronto.

June 10-13, National Soc. of Professional Engineers, annual meeting, Commodore Hotel, New York.

June 11-12, Southern Research Inst., "Undiscovered Earth" conference, Birmingham.

June 21-26, ASTM, annual meeting, Hotel Chalfonte-Haddon Hall, Atlantic City, N. J.

June 27, AIME Adirondack Section, field trip to Cabot Minerals Div., Willsboro, N. Y.

June 28-July 1, Rocky Mountain Coal Mining Inst., annual meeting, Antlers Hotel, Colorado Springs, Colo.

July 25, AIME Adirondack Section, field trip to New York Seaway and Federal Power Authority, Massena, N. Y.

Aug. 29, AIME Adirondack Section, field trip to Canadian Titanium Pigment Co., Varennes, Que., Canada; trip with wives, headquarters at Montreal.

Sept. 13-18, SME Minerals Beneficiation Division, American Chemical Soc. Colloid Chemistry Section, joint meeting on "Solid-Liquid Interphases," Atlantic City, N. J.

Sep. 14-17, American Mining Congress, Metal Mining & Industrial Minerals Convention, Denver.

Sept. 24-26, SME Industrial Minerals and Coal Divisions, joint meeting, Bedford Springs, Pa.

Sept. 26, AIME Adirondack Section, field trip to Ruberoid Co. asbestos operation, Hyde Park, Vt.

October, AIME Adirondack Section, field trip and football game, vicinity Syracuse, N. Y.

October, AIME Lehigh Valley Section, technical meeting.

Oct. 8-10, Exploration Drilling Symposium, trisponsors: Colorado School of Mines, Pennsylvania State University, and University of Minnesota; Pennsylvania State University, University Park, Pa.

Oct. 27-29, 1959 AIME-ASME Joint Solid Fuels Conference, Netherland-Hilton Hotel, Cincinnati.

Nov. 9-12, Society of Exploration Geophysicists, annual meeting, Biltmore Hotel, Los Angeles.

Dec. 4, AIME Lehigh Valley Section, ladies' night.

Dec. 7, AIME Arizona Section, annual meeting, Tucson, Ariz.

Feb. 14-18,1960, AIME Annual Meeting, Hotel Statler, New York.

MINING engineering

Vol. 11 NO. 5 **MAY 1959**

COVER *Photogrammetric mapping methods for mining use are symbolized on this month's cover by artist Herb McClure. For a survey of European and American applications, turn to the article on page 497. Results of this survey suggest savings—in time, men, and money.*

TECHNICAL ARTICLES

497 **Photogrammetric Methods and the Open Pit Mine** • *A. Tremari and P. I. Eimon*

502 **South African Mining—A Time to Invest?** • *H. S. Strouth*

506 **Railroad Car-Dumper Coal Sampling** • *W. R. Reichenstein and A. Bur*

509 **Designing Ore-Treatment Pilot Plants** • *R. D. Macdonald and F. M. Stephens, Jr.*

521 **Gyro-Compass Surveys Underground Workings and Boreholes** • *E. P. Pfleider and Otto Rellensmann*

527 **Recent Developments in Pebble Milling** • *B. S. Crocker*

531 **Midnite Mine: Geology and Development** • *R. F. Sheldon*

535 **Application of Electron Diffraction and Electron Microscopy to Mineral Engineering** • *J. E. Lawver and G. L. Samsel*

536 **Discussion**

JACKLING LECTURE, 1959

513 **Economic History of the Lake Superior Iron District** • *R. S. Archibald*

DEPARTMENTS

468 **Personnel**

476 **Information Section**

479 **Manufacturers News**

480A **Free Literature**

485 **Reporter**

489 **Trends**

493 **Drift: Mohole Signals Attention to Mining** • *Rixford A. Beals*

537 **SME Bulletin Board**

546 **Around the Sections**

547 **Personals**

552 **Obituaries**

556 **Professional Services**

560 **Advertisers Index**

FEATURED ITEMS

536B **SME Available Preprint List**

539 **How SME Obtains—And Spends—Its Money**

543 **Bedford Springs, Pa., Meeting of Coal and IndMD**

Address insertion orders and copy to MINING ENGINEERING, 29 W. 39th St., New York 18, N. Y. Send plates to: MINING ENGINEERING, c/o Lew A. Cummings Co. Inc., 215 Canal St., Manchester, N. H. Published monthly by the American Institute of Mining, Metallurgical, and Petroleum Engineers, Inc., 29 W. 39th St., New York 18, N. Y. Telephone: PEnnsylvania 6-9220; TWX NY 1-1304. Subscription $8 per year for non-AIME members in the U. S., & North, South, & Central America; $10 foreign; $6 for AIME members, or $4 additional for members only in combination with a subscription to "Journal of Metals" or "Journal of Petroleum Technology". Single copies, $.75; single copies foreign, $1.00; special issues, $1.50 AIME is not responsible for any statement made or opinion expressed in its publications.

Copyright 1959 by the American Institute of Mining, Metallurgical, and Petroleum Engineers, Inc.

Registered cable address, AIME, New York. Indexed in Engineering Index, Industrial Arts Index, and by National Research Bureau. Second class postage paid at New York, N. Y., and at Manchester, N. H. Number of copies printed of this issue 15,000.

no. 7 OF A SERIES

A "SOUND" APPROACH TO RIDING COMFORT

The "tuning out" of excessive shake and vibration by Oldsmobile engineers produces a comfortable, balanced ride that adds thousands of miles to the life of an automobile.

One of the most critical areas of engineering in today's automobile is "ride". It is critical because an unsatisfactory ride means an unsatisfactory automobile. To produce an over-all balanced and smooth ride, free from harshness and fatiguing vibration, Oldsmobile engineers begin the complex task of "tuning" the car in the early stages of a new model program. Not only is ride important from the comfort standpoint, but an improperly "tuned" car can literally shake itself apart after several thousand miles.

The tuning operation is a series of intricate tests that determine a car's "shake" characteristics—where and how much the metal bends and twists. To produce beaming and torsional moments, a mechanical oscillator is attached to the frame and vibrates the car in a frequency range of 7½ to 15 cycles per second. To measure the displacement of the metal, a velocity pick-up is attached directly to the area under study. As the metal vibrates, a signal is produced by the pick-up and is fed to a vibration meter where it is integrated. The resulting signal is then transmitted to an X-Y plotter that instantly converts it into a continuous magnitude-vs.-frequency trace.

With this valuable information, refining can begin by altering the structure of the various component parts. A complex network of infinite variation must be analyzed intensively to produce the mark of quality that stamps every Oldsmobile.

Over the years, Oldsmobile's reputation for quality manufacturing and precision engineering has grown, step by step, until today it is a car of recognized distinction—in a class by itself. Oldsmobile's durability and long service life is further attested to by its continued leadership in resale value. You owe it to yourself to first examine, then test-drive, a truly outstanding automobile—the 1959 Oldsmobile. Visit your Local Authorized Oldsmobile Quality Dealer as soon as possible.

OLDSMOBILE DIVISION, GENERAL MOTORS CORPORATION

OLDSMOBILE

Pioneer in Progressive Engineering ...Famous for Quality Manufacturing

metal mining modernization

New ROM screen shakes off brutal battering

Designed to team up with primary crushers to handle toughest jobs in any metal mining flow

There's an Allis-Chalmers screen for every metal mining application

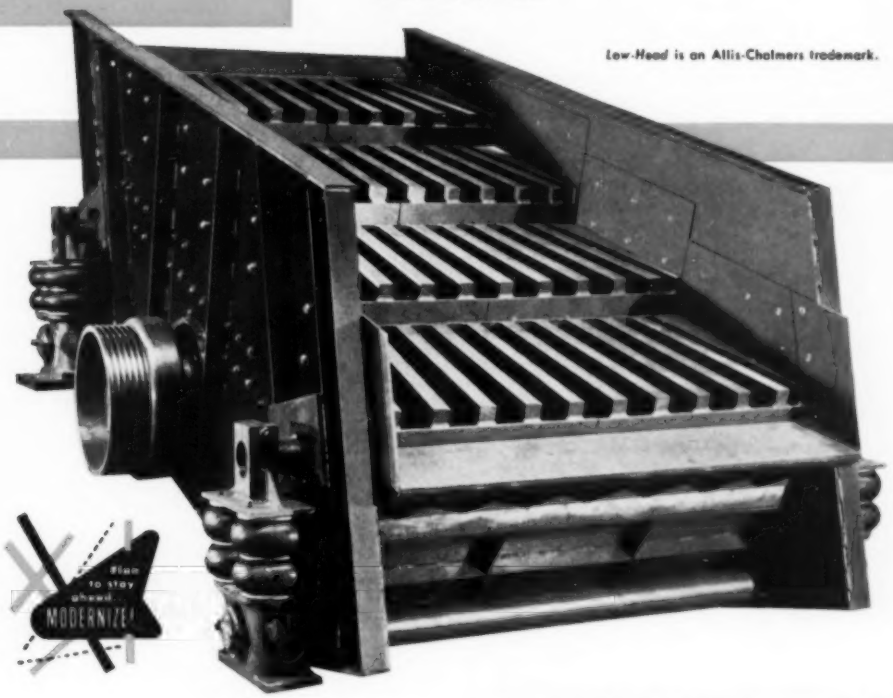
A complete line of inclined screens for scalping, sizing and cyclone plant application; plus the industry's most popular screen — the Low-Head horizontal screen for pre-wetting, washing and sizing, media recovery.

Large volume requirements . . . single pieces of ore weighing as much as four tons . . . such are the demanding conditions under which this screen is setting new performance standards.

Built for heavy-duty service, its husky support frame ignores persistent pounding. Its giant bearings are designed for long life. And even if hundreds of pounds of sticky material cling to its body, this *extra heavy duty* screen still performs efficiently. Vibration isolation is handled effectively by either air springs or steel coil springs.

For complete information, see your Allis-Chalmers representative or write for Bulletin 07B8368, Allis-Chalmers, Industrial Equipment Division, Milwaukee 1, Wisconsin. In Canada, write Canadian Allis-Chalmers Ltd., Box 37, Montreal, Quebec.

Low-Head is an Allis-Chalmers trademark.



ALLIS-CHALMERS

A-5941-MM

PERSONNEL

THESE items are listings of the Engineering Societies Personnel Service Inc. This Service, which cooperates with the national societies of Civil; Electrical; Mechanical; Mining, Metallurgical, and Petroleum Engineers, is available to all engineers, members and nonmembers, and is operated on a nonprofit basis. If you are interested in any of these listings, and are not registered, you may apply by letter or resume and mail to the office nearest your place of residence, with the understanding that should you secure a position as a result of these listings you will pay the regular employment fee of 5 pct of the first year's salary if a nonmember, or 4 pct if a member. Also, that you will agree to sign our placement fee agreement which will be mailed to you immediately, by our office, after receiving your application. In sending applications be sure to list the key and job number. When making application for a position, include 8¢ in stamps for forwarding application to the employer and for returning when possible. A weekly bulletin of engineering positions open is available at a subscription rate of $3.50 per quarter or $12 per annum for members, $4.50 per quarter or $14 per annum for nonmembers, payable in advance. Local offices of the Personnel Service are at 8 W. 40th St., **New York 18**; 57 Post St., **San Francisco**; 84 E. Randolph St., **Chicago 1**.

MEN AVAILABLE

Assistant Mine Superintendent of Development Engineering, B.S. in mining, M.S. in Ind.E., age 30. Experienced in industrial development, report writing, financial analysis, editorial writing, exploration development work and laboratory pilot plant work. Desires position as assistant mine or plant superintendent, or project or staff development engineer. Single. M-928-Chicago.

Plant Engineer, age 42, with three and one-half years as assistant plant engineer; five and one-half years as assistant maintenance superintendent; two years as safety and maintenance superintendent and one and one-half years as terminal manager. Prefers Chicago, north, or northwest. M-932-Chicago.

Sales Engineer, B.S. in mining engineering, age 30. Has six years training as sales engineer of magnetic separators. Responsible for cost estimating, pricing, sales and service. Makes recommendations on installations and machine design. Very familiar with equipment and flowsheets used in iron ore beneficiation plants and heavy media plants on all ores. Prefers U. S. M-472.

Executive, age 53, with background in mining and manufacturing, exploration, development, production, all phases of engineering, flow sheets, layouts, materials handling, underground and large quarries, metals and metallics, gypsum and limestone. Also experienced in complete evaluation of deposits and businesses. Staff, consulting, or trouble shooting of prime interest. Foreign assignment on intermittent consulting basis only. M-473.

Resident Manager, E.M., age 43. Has had 20 years in mining, open pit and underground. Managerial, direct supervision, and engineering experience. Broad background with special interest in cost control. Successful experience, full responsibility, completely integrated foreign mine-mill unit. Good organizer. Location, immaterial. M-474.

Mining Engineer Trainee, B.S. in mining engineering, age 25. Naval Engineering Officer, shipboard and ashore. Three years miner; underground, one-half year; surveyor underground, one-half year; draftsman, water utility, one and one-half years. Location, anywhere, M-401-San Francisco.

Mining Engineer, E.M. degree, age 31. Six years mining engineering includes three years as supervisor in open pit uranium mine. Desires position in technical sales, consulting or mine supervisory work. M-310-San Francisco.

Mining Geologist, B.S. in geology, one year graduate school, age 32. Nine years spent in engineering geology; region-wide mineral exploration for base and rare metals, nuclear source materials; property development. Prefer west or northwest. M-475.

Mining Engineer, B.S. in E.M., age 32. One and one half years experience in engineering, including mine design, layout and shaft sinking; two years spent as mine foreman of underground metal mine in Latin America. Location, immaterial. M-476.

Executive Assistant, Attorney, E.M. and LL.B. degrees, age 34. Experienced in engineering, management, and legal phases of mining. Accustomed to working with top management in high level negotiating. Desire position with opportunity for growth and responsibility. Will relocate and travel. M-477.

Mining Engineer, age 39. Twelve years experience both domestic and foreign. Four years managerial positions. Desire to change jobs. Available July 1. M-478.

Superintendent, Exploration Manager, Liaison Officer, M.Sc. in mining and metallurgy, age 47. Twenty-two years exploration including successful concession negotiations also in Latin America. Placer operations; all management phases of open pit operations, including personnel, purchasing, cost accounting, liaison. Custom smelter metallurgy: tin, lead, copper, bismuth, tungsten, vanadium, including research and ore buying. Multilingual. Prefer U. S., Latin America; second choice, Europe, South Africa. M-936-Chicago.

Project or Resident Construction Engineer, B.S., age 34. Desire construction management position with mining firm, consultant or cement producer. Eight years experience in supervision of contractors, estimating and negotiation in large commercial and steel industry projects. Location, immaterial, will consider foreign. M-940-Chicago.

Geologist, B.S., M.S., age 28. Two and one-half years experience with large mining company, both surface and underground work as geologist. Prefer U. S. M-1079-San Francisco.

Staff Mining Engineer or Staff Mining Geologist, A.B. in mining geology, age 35. Ten years open pit and underground mining experience as geologist, geological engineer, and mining engineer at iron, tungsten, and uranium operations. Especially valuable training in property evaluations and report writing. Will consider any location but prefer east or west coast. M-1352-San Francisco.

Geologist, B.A., age 28. Seven months experience exploring, mapping, and evaluation in New Hampshire and Province of Quebec. Responsible for developing ore reserves for feldspar mining company. Just completed 3 years military service with training and experience in flying and management. M-479.

(Continued on page 541)

FOR SALE: 800 PATENTED MINING CLAIMS, 7500 ACRES, GOLD, SILVER, LEAD, ZINC, AND COPPER. SILVERTON, COLORADO, ONE OF THE RICHEST PRECIOUS METAL DISTRICTS IN THE WORLD. WILL SELL (RETAINING A 3% ROYALTY) FOR LESS THAN THE COST OF PATENT AND TAXES PAID. 50% HAS HEAVY TIMBER. TERMS, U.S. MINING ENGINEERING MAP REPORT, AND BLUE PRINTS, ETC. THIS IS SURFACE VEINS AND ORE DEPOSITS, NOT 2,000 TO 3,000 FEET DEEP LIKE LEADVILLE AND CRIPPLE CREEK. GO ON VACATION THERE THIS SUMMER AND SEE WITH YOUR NAKED EYES. $100.00 PER ACRE.

H. C. SPRINKLE
P. O. BOX 1835
DURHAM, N. C.

POSITION OPEN—General Manager, to direct operations of uranium mine and mill. Should have technical mining background and administrative experience. Submit complete record and references. Salary, open. Location, western states.

Box 7-ME AIME
29 West 39th St. New York 18

metal mining modernization

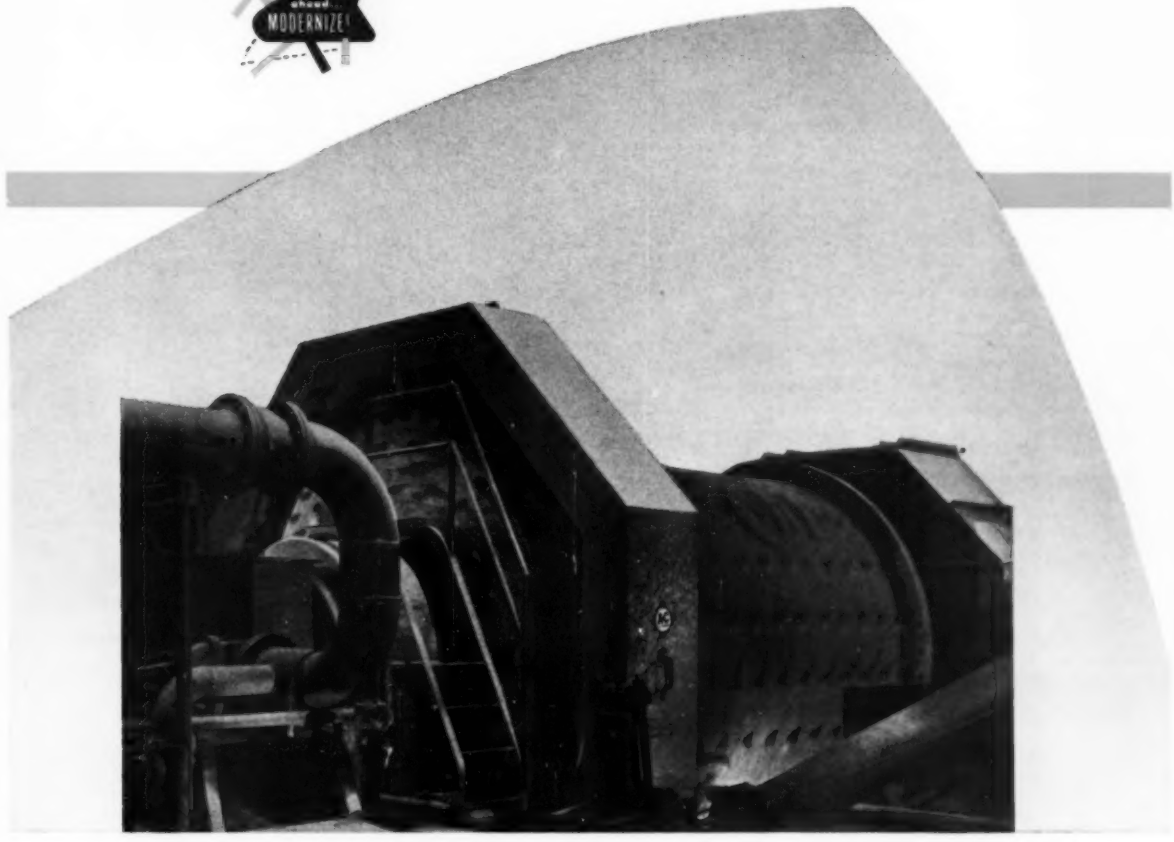
Grinding mills grow... Operating costs shrink

2000-hp mill does work of multiple units ...at far less cost

Plan to stay ahead MODERNIZE!

It's the big mill that grinds out profits. Want proof? In a typical installation, a giant 13 by 20-ft, 2000-hp Allis-Chalmers mill replaced two 10½ by 17 units. Operating costs were cut by a whopping 25% without losing one ounce of capacity.

Grinding mills are on the grow. The single mill conserves floor space and affords better quality control with its improved circuits. Watch for the 2500 and 3000-hp Allis-Chalmers mills soon to be announced.



See your A-C representative or write Allis-Chalmers, Industrial Equipment Division, Milwaukee 1, Wisconsin. In Canada, write Canadian Allis-Chalmers Ltd., Box 37, Montreal, Quebec.

ALLIS-CHALMERS

A-5936

One man operated GISMO® Transloader

- . . . with round-trip travel 1,600 feet
- On shorter hauls tonnage ranges up to 2-tons a minute.
- On longer hauls, tonnage ranges down to 1-ton a minute.

This HIGH tonnage production is accomplished by:

One Man
One S-D Gismo Transloader

How can one man and one piece of equipment do so much work? Because the Sanford-Day Gismo Transloader is BOTH a mucking-machine and a truck ALL-IN-ONE!

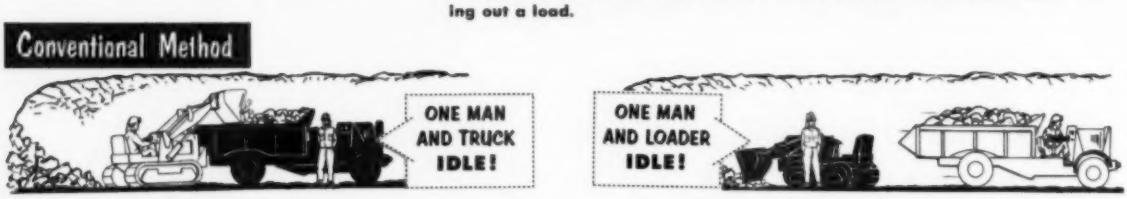
It is a high-speed transport — up to 20-miles per hour either direction! The fact it self-loads enables you to completely eliminate idle time of both men and equipment! Therefore, less capital investment required for additional equipment and manpower to do the job.

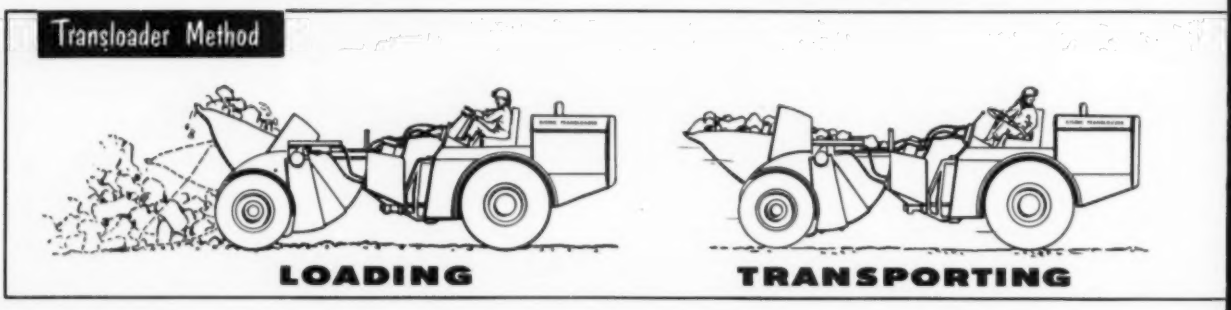
In conventional loading of materials, the loader is dependent on auxiliary equipment such as truck or shuttle car, etc. The loader cannot operate without the auxiliary conveyance. Neither does the haulage system operate while being loaded. Thus idling of men and equipment.

Compare this with the S-D Gismo Transloader. When Transloader is operating, man and equipment are working all the time; either mucking or transporting to dumping point! NEITHER THE TRANSLOADER NOR ITS OPERATOR ARE EVER IDLE! They are continuously at work in uninterrupted cycles!

Visualize one or several S-D Gismo Transloaders, each with only one man, MUCKING AND HAULING in your development or production work. Savings are tremendous! Write or call us today. *Manufactured by Sanford-Day Iron Works, Inc., Knoxville, Tenn.*

This photograph catches the action of the S-D Gismo Transloader mucking out a load.

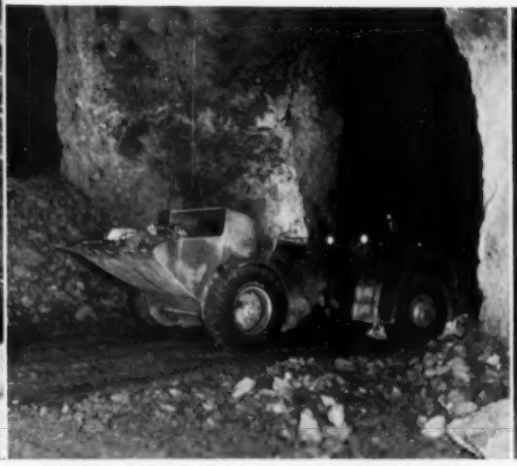




"Mucks-Hauls-Dumps" 100-tons an hour!

Here you see S-D Gismo Transloader with large, wide dipper down under hard rock. Transloader makes its own roadways and cleans-up completely . . . also moves large boulders for secondary blasting.

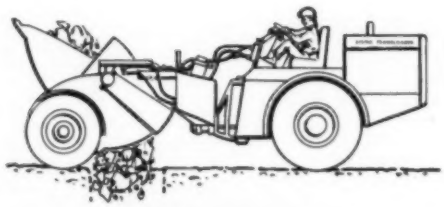
. . . and here is dipper raised with full load. This high-powered, high-speed Transloader operates on grades, in favor or against the load . . . negotiates, turns, etc.



This tramming scene (on way to raise) shows S-D Gismo Transloader as truck-transport.

Here load is being dumped into raise. Transloader also backfills waste, or dumps directly into bin . . . or by simple ramps over trucks, cars, conveyors, etc.

THE GISMO TRANSLOADER, rubber-tired Gismo Self-Loading Transport, is an advanced equipment development that is a perfectly natural result of the performance of the Gismo powered by crawler-mounted tractors developed a few years ago and doing an outstanding job in mechanized mining today!



DUMPING

SANFORD-DAY

KNOXVILLE, TENNESSEE

- S-D Mine Cars, all types and kinds.
- Precision S-D Mine Wheels.
- Tough, year-after-year wheel service by special S-D wheel Hard-Facing Process (this can really save you money and eliminate downtime).
- S-D "Brownie" Hoists. • S-D Car Spotters.
- S-D Mine Sheaves and Rollers.
- S-D Slusher-Trains for mining and construction industries.
- S-D Gismo Transloader for mining and construction industries.

The Standard of Comparison for UNIFORMITY

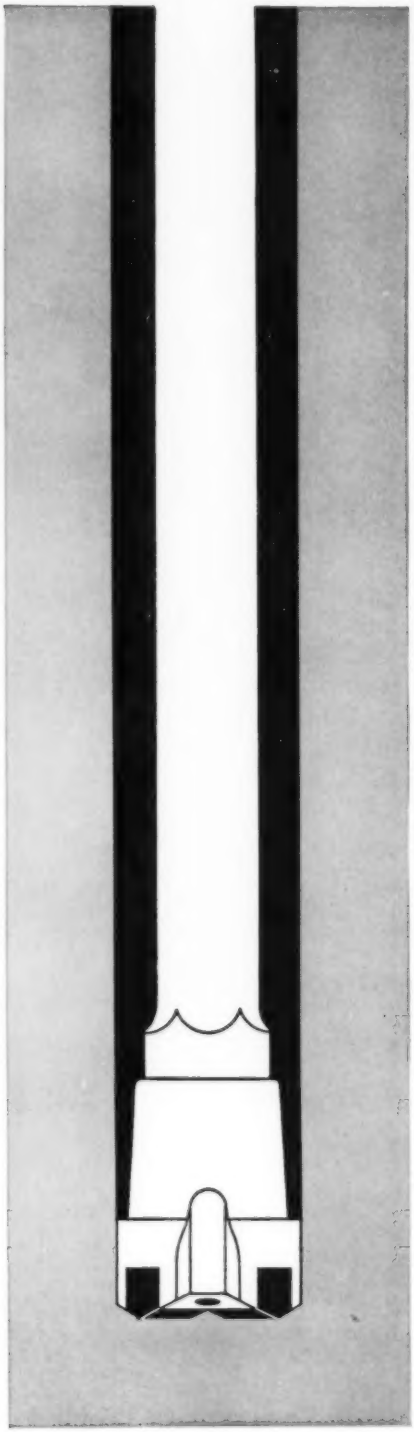
The alloying, forging and heat treating techniques used by Sheffield assure uniform quality. Fine, dense grain structure and the proved combination of hardness and toughness extend to the very core of a Moly-Cop ball. That's why Moly-Cops retain their spherical shape longer, save charging and down-time, and give you a better, longer grind at lowest cost per ton.

New steels are born at Armco

SHEFFIELD DIVISION

ARMCO STEEL CORPORATION

OTHER DIVISIONS AND SUBSIDIARIES: Armco Division • The National Supply Company • Armco Drainage & Metal Products, Inc. • The Armco International Corporation • Union Wire Rope Corporation • Southwest Steel Products



There's More Footage and Greater Economy in a Joy TC Bit

Here's why . . . Joy bit blanks are precision machined from a fine alloy steel, and a controlled heat treating process adds strength to give rugged service and long life. The carbide insert, a special grade selected for its extra footage-producing ability, is brazed to the bit blank by an exclusive process. This provides a super tough bond between the carbide and the bit blank—there's no lost time due to lost carbides.

These features, plus the excellent chipway design that provides maximum hole cleaning ability, keep Joy bits drilling longer. You get more hole per bit . . . more hole per shift . . . more production.

For proof of performance, contact your Joy representative. He will be glad to demonstrate Joy Tungsten Carbide Bits.

Write for Bulletin 295-7

YOU'LL FIND YOUR BIT SIZE IN THIS CHART

SHOULDER DRIVE	BOTTOM DRIVE	TAPER SOCKET
1½"	*2½"	1¼"
1⅝"	*2¾"	1⅜"
1¾"	*3"	1½"
1⅞"	*3¼"	1⅝"
2"	*3½"	1¾"
2⅛"	*4"	
2¼"	*4½"	
2⅜"	*5"	
2½"	†4"	
2¾"	†4½"	
3"	†5½"	
*3½"	†6"	
*4"		
*4½"		

NOTE: * x-type.
†Rose design
Others are cross type.

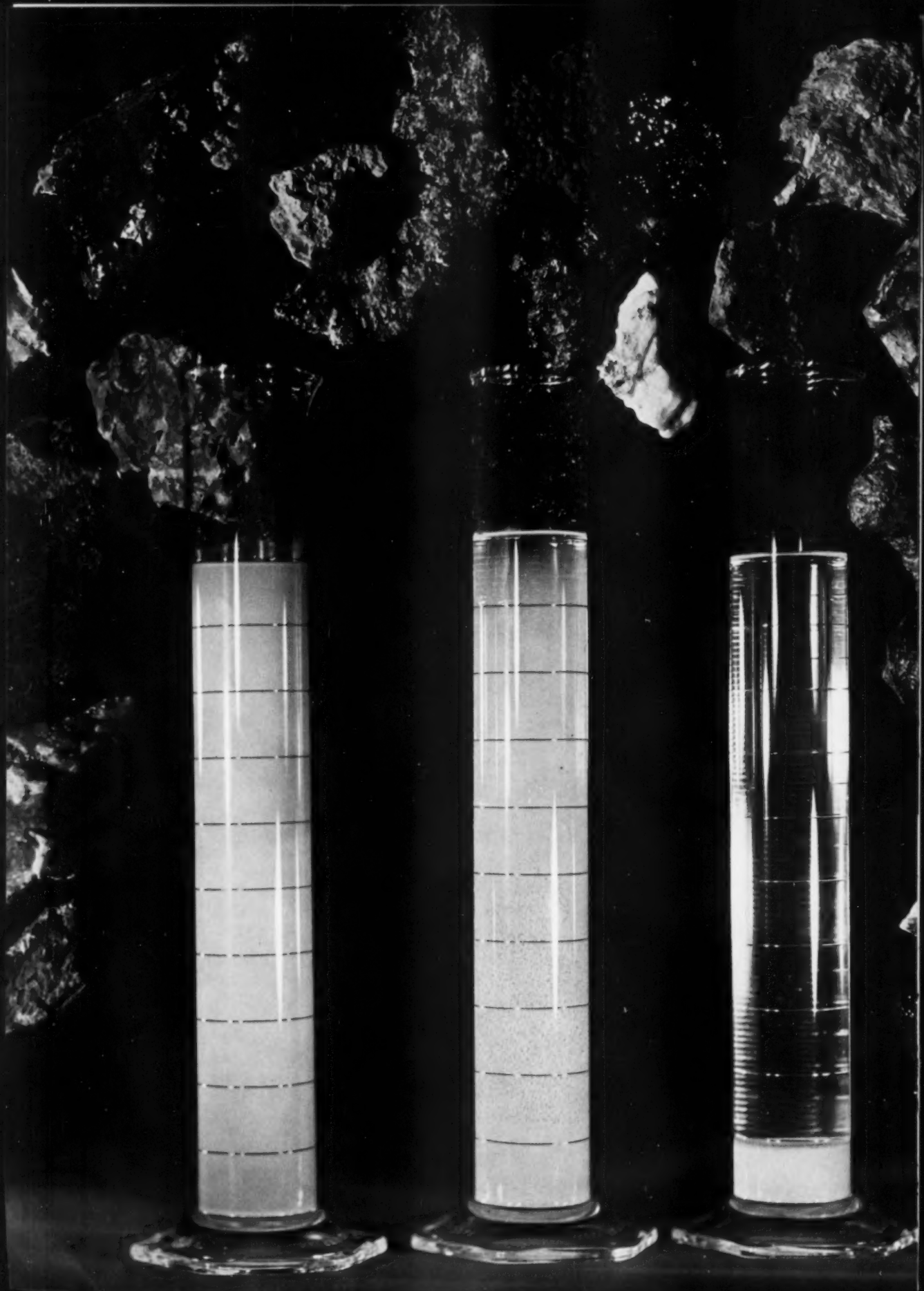
EQUIPMENT FOR MINING . . . FOR ALL INDUSTRY

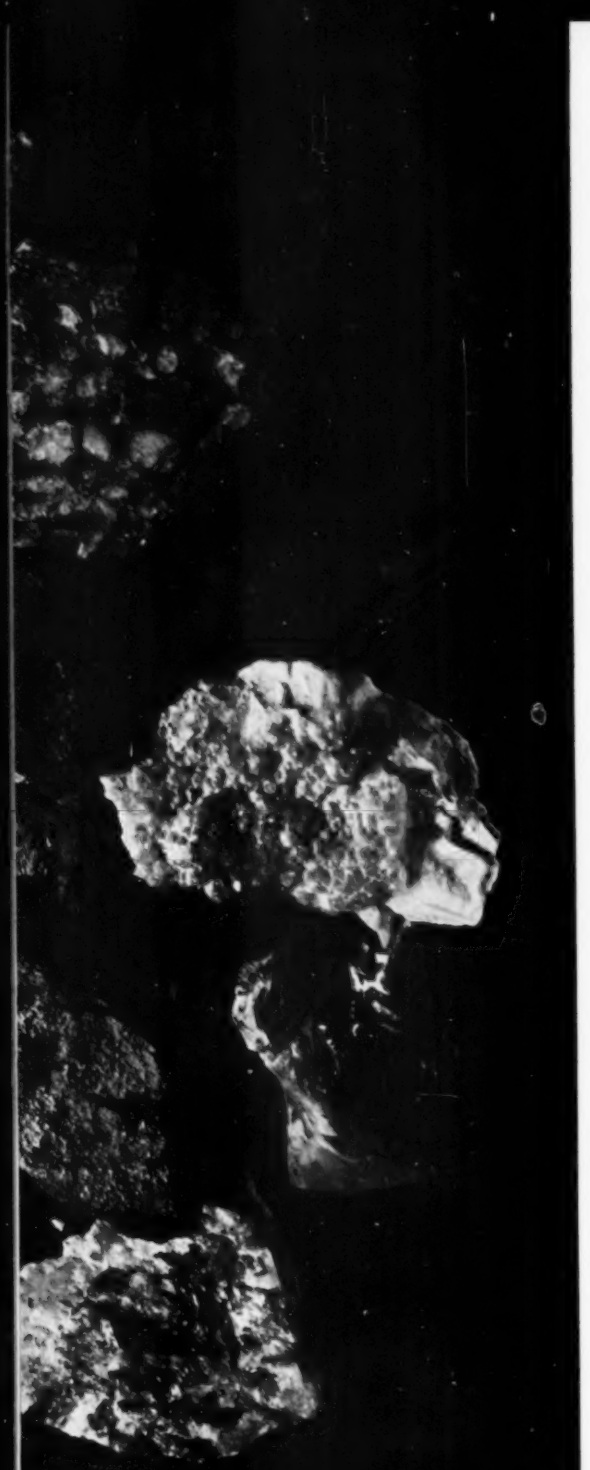
JOY

Joy Manufacturing Company
Oliver Building, Pittsburgh 22, Pa.

In Canada: Joy Manufacturing Company (Canada) Limited, Galt, Ontario

WSW M-7810-295





Non-metallic slimes settling with the aid of SUPERFLOC 16 Flocculant.

Clockwise from the bottom left the mineral specimens are: Orpiment - Fluorite Azurite - Chrysocolla - Kyanite - Bauxite Marmatite, dolomite - Carnotite - Native silver in calcite - Malachite - Native copper Heterogenite - Gold quartz - Pitchblende, gummite - Chalcanthite, pyrolusite in aplite - Gold-bearing conglomerate - Ilmenite - Native copper - Covellite - Amethyst Carnotite - Silica - Ferberite - Anthracite

SUPERFLOC* 16

FLOCCULANT

NOW COMMERCIALLY AVAILABLE

A new, highly-superior flocculating agent has been developed by Cyanamid—SUPERFLOC 16 Flocculant. This high molecular weight polyacrylamide product has consistently out-performed other synthetic and natural polymers in plant and laboratory trials as a filtration and settling aid.

Available in high bulk density, essentially dust-free form, this powerful new flocculant comes in both 50-pound bags and in 100-pound net fiber drums. Its physical properties make for easy feeding, wetting and dissolving.

Cyanamid continues to offer AEROFLOC* 3171 Reagent for those operations where a less-powerful flocculant will perform satisfactorily.

Write for free samples of these products and technical literature.

*Trademark

CYANAMID

AMERICAN CYANAMID COMPANY

EXPLOSIVES AND MINING CHEMICALS DEPARTMENT

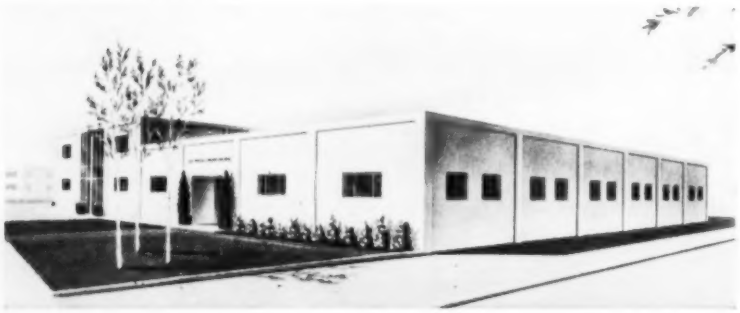
CYANAMID INTERNATIONAL — *Mining Chemicals Department*
Cable Address: — Cyanamid, New York

30 ROCKEFELLER PLAZA, NEW YORK 20, N. Y.

ACOJE MINING COMPANY CHROME OPERATIONS, ZAMBALES, PHILIPPINES

Installed in 1955 and paid for with savings in 3 weeks by increased recovery, Krebs Cyclones at Acoje have now operated for over 3 years with no replacement of Krebs Molded Rubber Liners. Scores of other operations have also made gains by the desliming and upgrading performance of Krebs Cyclones used ahead of tables, spirals, classifiers, thickeners, sizers and screens.

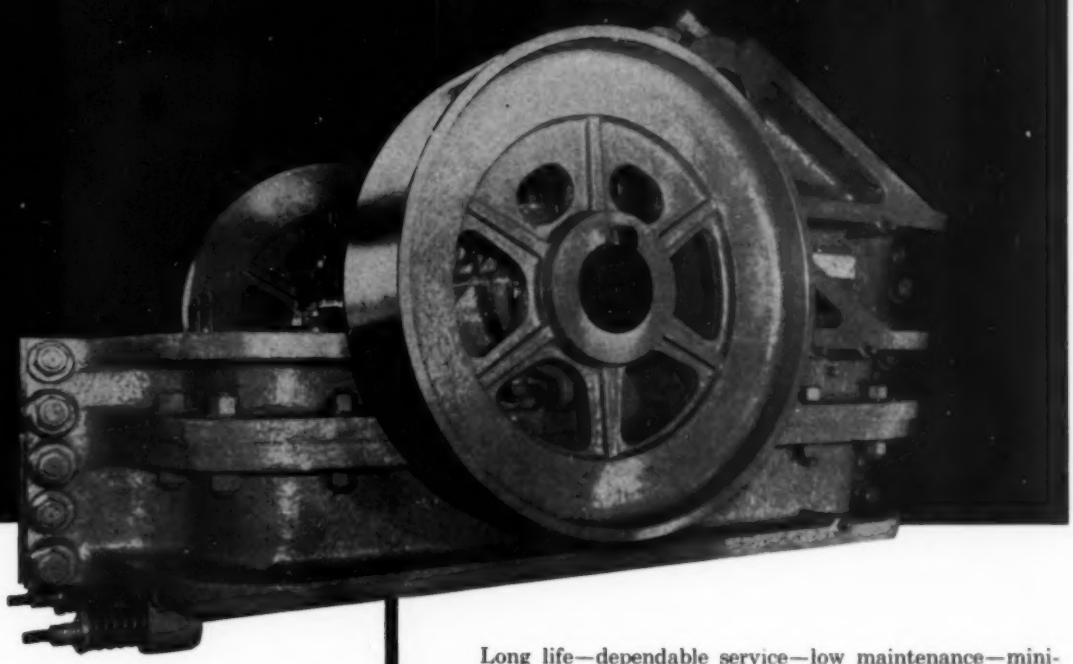
Equipment Engineers' Pilot Plant in Palo Alto, California, made full scale studies of Acoje samples prior to the installation and results were confirmed in the Acoje plant. Our Palo Alto facilities are being expanded that we may continue to serve the Mineral Industry more effectively.



EQUIPMENT ENGINEERS INC.

737 LOMA VERDE AVENUE
PALO ALTO, CALIFORNIA

KENNEDY JAW CRUSHERS



The KENNEDY Overhead Eccentric Jaw Crusher features a massive, one-piece, arc welded steel plate frame, and is available in standard sizes from 10" x 36" to 36" x 42".

Long life—dependable service—low maintenance—minimum power—high production—make KENNEDY Jaw Crushers the first choice of all who buy because of proven performance and low year-to-year cost.

Exclusive features of the KENNEDY Jaw Crusher

- Cast Meehanite or steel frame.
- Counterbalanced flywheel lifts pitman at bottom of stroke. Makes starting easier.
- Split frame design distributes stresses evenly. There can be no failures at the corners.
- No loss of power due to "weaving" and misalignment common to ordinary 4-piece crusher frames.
- Rocking toggles require no lubrication.
- Each jaw bears exactly half the load because both are mounted at the same angle. No power is wasted in lifting the charge.
- Jaw plates are interchangeable and reversible. Shaft is integral with swing jaw.
- Available in standard sizes from 7" x 10" to 66" x 84".

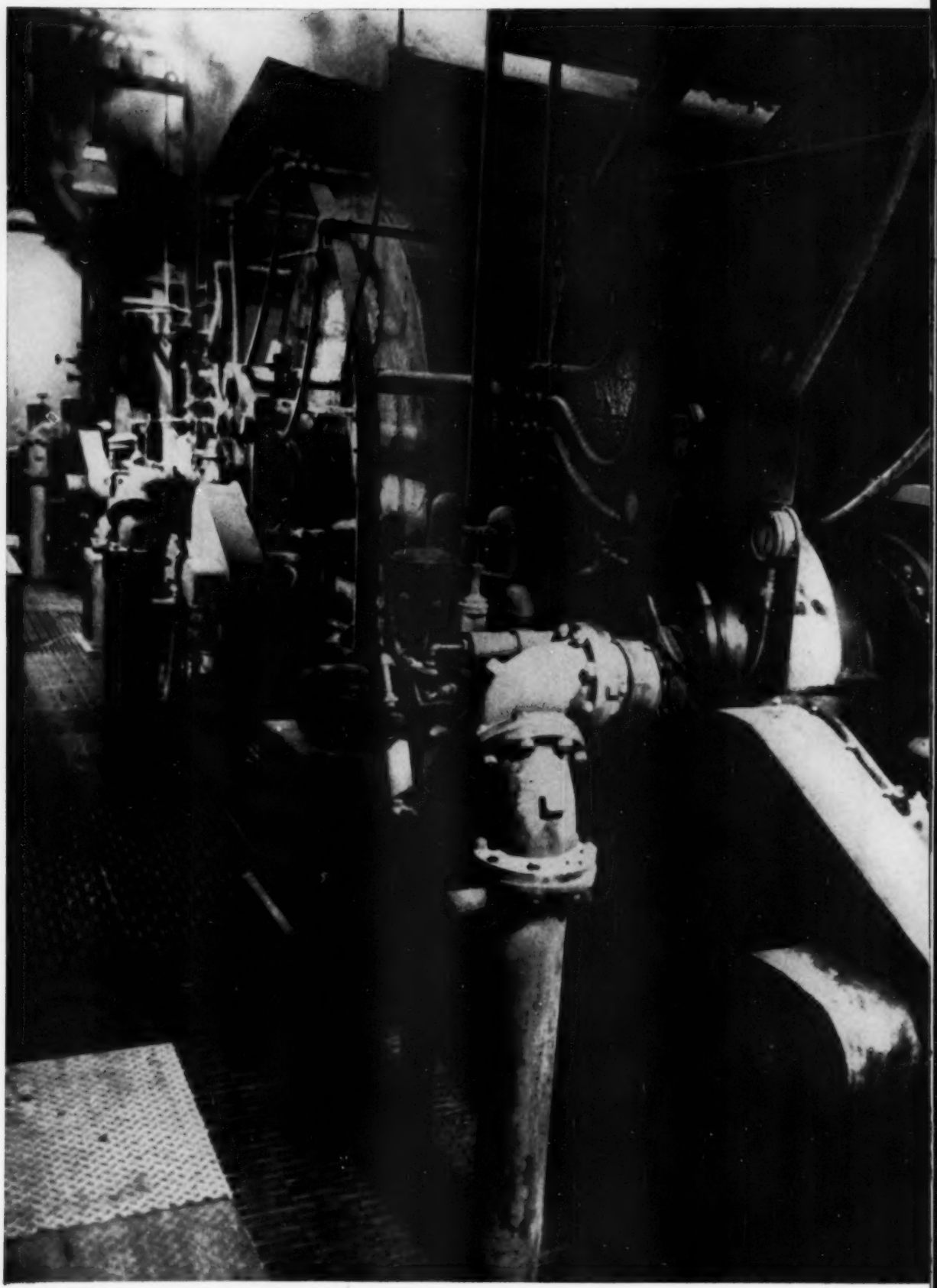
Send for complete information on KENNEDY Crushers.

KENNEDY VAN SAUN

MANUFACTURING & ENGINEERING CORPORATION

405 PARK AVENUE, NEW YORK 22, N.Y. • FACTORY: DANVILLE, PA.

Primary & Secondary Gyratory Crushers • Jaw Crushers • Roll Crushers • Impact Breakers • Hammer Mills • Rod & Ball Mills • Kilns • Dryers • Screens • Mechanical & Pneumatic Conveyors • Complete Crushing, Lime, Cement & Carbon Paste Plants. KENNEDY Research & Testing Service.



SUCCESS STORY AT ANACONDA'S GRANTS, NEW MEXICO, URANIUM MILL

tonnage up, maintenance down, using OLIVER DRUM FILTERS with new snap in-out rubber grids

Ore from the famous Jackpile ore body is processed at Anaconda's Grants, New Mexico, carbonate leach uranium mill. In the 1954 expansion program, three Oliver Continuous Rotary Drum-Type Filters were substituted for batch filtration equipment previously used. Easily removable snap in-out support grids, an exclusive Dorr-Oliver feature, were originally of wire, but have since been replaced by the Company's recently developed rubber waffle-type.

The Oliver filters have been in continuous operation since Spring, 1955, with no shutdowns except for cover changes. Since installation of the rubber grids, tonnage handled has been nearly doubled from 300 to 600 tons per day. Cloth life averages 60 days. The combination of high production and exceptionally low maintenance expense has resulted in substantial cost reductions per ton of ore treated.

Filtration is carried out in three stages, with repulping between stages. Additional Dorr-Oliver equipment includes O.D.S. Diaphragm Type Pumps on Filtrate and Slurry Service. Slurry handled contains 50% solids. There are also acid-proof Dorr FH Classifiers and DorrClones on acid leaching service and Dorr Agitators on autoclave discharge. A noteworthy feature is the use of Dow "Seperan" to improve filtration. As a result, loss of water solubles has been reduced to a very low level.

The know-how of Dorr-Oliver engineers is based on over 50 years of world-wide experience in handling every type of filtration problem. For more information on Dorr-Oliver equipment or for assistance on your particular problems, write to Dorr-Oliver Incorporated, Stamford, Connecticut.

DORR-OLIVER
INCORPORATED
WORLD-WIDE RESEARCH • ENGINEERING • EQUIPMENT
STAMFORD • CONNECTICUT • U. S. A.

Photo shows installation of 3 Oliver Drum Filters at Anaconda Copper Mining Company's uranium mill, Grants, New Mexico. Filters are 11'6" diameter x 18' face, with snap in-out waffle type rubber grids. Each filter handles about 600 TPD of ore.

Seperan, Reg. Trademark Dow Chemical Co.

DorrClone and Oliver are trademarks, Reg. T.M. U.S. Pat. Off.

Mineral Information

An International Directory of Engineering Source Material

Order directly from the publisher all books listed below except those marked • • • The books so marked (• • •) can be purchased through AIME, usually at a discount. Address Irene K. Sharp, AIME Book Dept., 29 W. 39 St., New York 18, N. Y.

BOOKS

Mineralogy and Geology of Radioactive Raw Materials, by E. William Heinrich, *McGraw Hill Book Co. Inc.*, 654 pp., $14.50, 1958—A comprehensive survey of the many radioactive minerals, their properties and manner of occurrence, has been prepared by a professor of mineralogy at the University of Michigan who is an AIME member. The book also attempts a detailed genetic classification of uranium and thorium deposits.

The Physical Chemistry of Steelmaking, edited by John F. Elliott, co-published by *The Technology Press of Massachusetts Inst. of Technology* and *John Wiley & Sons Inc.*, 257 pp., $15, 1958—Proceedings of the conference, The Physical Chemistry of Iron and Steelmaking in 1956, are presented. The papers summarize the thinking of a number of leading metallurgists. Current applications and research progress are outlined.

Cost Manual For Piping and Mechanical Construction, by Herbert Herkimer, *Chemical Publishing Co. Inc.*, 212 5th Ave., New York, N. Y., 176 pp., $10, 1958—The purpose of this volume is to help estimators arrive at reliable figures and to help plant maintenance managers check estimates submitted to them. Types of estimates, standard hours, direct costs, pay statements, and tables are presented.

Civil Engineering Handbook, edited by Leonard C. Urquhart, 4th edition, *McGraw-Hill Book Co. Inc.*, 1184 pp., $17.50, 1959—This handbook, written by various authorities, covers mechanics of materials, stresses in framed structures, steel design, highway and airport engineering, water supply, and other aspects of civil engineering.

Chemical Processing of Nuclear Fuels, by F. S. Martin and G. L. Miles, *Academic Press Inc.*, 111 5th Ave., New York 3, N. Y., 242 pp., $7.50, 1958—An introduction to the problems of chemical processing of the fuel after it has been irradiated in a reactor. The major part deals with aqueous processes, including solvent extraction, ion exchange, and precipitation processes.

Uranium and Thorium, by L. Grainger, *Pitman Publishing Co.*, 2 West 45th St., New York 36, N. Y., 204 pp., $6, 1958—A study of interest to those dealing with fissionable materials, which summarizes recently published material. Occurrence and extraction, chemical and physical properties, health hazards, and use as nuclear fuels are covered.

Underground Lighting in Mines, Shafts, and Tunnels, by A. Roberts, *The Macmillan Co.*, 292 pp., $12.75, 1958—The author begins with definitions and units now used in lighting and with description of elements of photometry essential to correct lighting design. Applications and equipment are also discussed.

Mining Explosives, by R. McAdam and R. Westwater, *Oliver and Boyd*, Edinburgh, Scotland, 187 pp., $2.95 (21s), 1958—The characteristics, composition, and construction of blasting explosives and accessories are described. This is followed by the blasting techniques used in coal mines, metalliferous mines, open-pit workings, and quarries. Safety aspects are considered.

Bergbaumechanik, by W. Ostermann, 5th edition, *Springer-Verlag*, Berlin, Germany, 612 pp., approx. $8.60 (36 DM), 1958—This comprehensive treatment of mechanics for mining engineers is intended both as a text for students and a handbook for practicing engineers. There are four major sections: statics of solid bodies; dynamics of solid bodies; strength of materials; hydraulics and fluid dynamics.

Atlas of Canada, prepared by the Geographical Branch, *Dept. of Mines and Technical Surveys,* Superintendent of Publications, The Queen's Printer, Ottawa, Canada, 450 maps, 110 sheets, $25, 1958—This sequence of maps characterizes and gives meaning to the internal development of Canada from the days of discovery to the present. Land, water, and atmospheric resources are pictured; the wide range of vegetation and animal life is shown; population distribution plus origins and religions, birth, marriage, and death rates of the people are covered along with the economic activities of the nation.

Professional Engineer's License Examination Library, *McGraw-Hill Book Co. Inc.*, 2 vols.: **How to Become a Professional Engineer** by John D. Constance, and **Professional Engineer's Examination Questions and Answers,** by William S. LaLonde, Jr., 724 pp., 1958—These two volumes comprise the library offered to help answer questions and prepare candidates for the Professional Engineer's license. Regulations and procedures are outlined and 500 questions from the examinations are given as examples.

Price List of *Johnson Reprint Corp.*, 111 5th Ave., New York 3, N. Y., 20 pp., 1958—The journals and books listed in this catalogue have long been out of print and in great demand. Reprints of these publications will enable libraries and scientists to complete their holdings. Volumes of *American Geophysical Union: Transactions; Engineering Index; Journal of Geology;* and many others are included.

Perspectives On Conservation, edited by Henry Jarrett, *The Johns Hopkins Press,* Baltimore 18, Md., 272 pp., index, $5,—The idea of conserving natural resources has been a major force in American thought and action. This series of essays was first presented at the 1958 Forum of Resources for the Future.

Punched Cards: Their Applications to Science and Industry, edited by Robert S. Casey and others, 2nd edition, *Reinhold Publishing Corp.*, 697 pp., $15, 1958—Beginning with an introduction to the use of a simple punched-card file, the book continues with case histories of punched-card applications including Peek-a-Boo System, Uniterm System, and mechanized coding.

STATE PUBLICATIONS

Arizona

Order From:
Arizona Bureau of Mines
University of Arizona
Tucson, Ariz.

Geologic Map of Mohave County, Arizona, 75¢, 1959.

California

Order From:
California Div. of Mines
Ferry Bldg.
San Francisco 11, Calif.

Index of Topographic Mapping in California, Bulletin 79, $2, 1959.

Connecticut

Order From:
Robert C. Sale
State Librarian
State Library
Hartford 15, Conn.

Explanatory Text for Preliminary Geological Map of Connecticut, 1956, Bulletin 84, $1, 1959.

Twenty-Eighth Biennial Report of the Commissioners of the State Geological and Natural History Survey, 1957-1958, Bulletin 90, 20¢, 1959.

Illinois

Order From:
Illinois State Geological Survey
Natural Resources Bldg.
Urbana, Ill.

Electrokinetics—1. Electroviscosity and the Flow of Reservoir Fluids, Circular 263, gratis, 1959.

Determination of Acidic Groups in Coal Tars By Non-Aqueous Titration, Circular 264, gratis, 1959.

Indiana

Order From:
Dept. of Conservation
Publications Section,
Geological Survey
Indiana University
Bloomington, Ind.

Miospore Analysis of the Pottsville Coals of Indiana, Bulletin 13, $1.50, 1958.

Cambrian and Ordovician Stratigraphy and Oil and Gas Possibilities in Indiana, Bulletin 14, $1.50, 1959.

Distribution, Structure, and Mined Areas of Coals in Spencer County, Ind., Preliminary Coal Map No. 8, 50¢, 1959.

Geology and Coal Deposits of the Seelyville Quadrangle, Vigo County, Ind., U.S.G.S. Coal Investigations Map No. C27, $1, 1959.

Interpretation of an Aeromagnetic Survey of Indiana, U.S.G.S. Professional Paper 316-B, 75¢, 1959.

Directory of Sand and Gravel Producers in Indiana, Directory No. 6, 50¢, 1959.

Lightweight Aggregate Potentialities of Some Indiana Shales, Report of Progress No. 12, 75¢, 1959.

Kansas

Order From:
State Geological Survey
University of Kansas
Lawrence, Kan.

Quaternary Geology and Ground-Water Resources of Kansas River Valley between Bonner Springs and Lawrence, Kansas, Bulletin 130, Part 1, 75¢, 1958.

Environment of Deposition of the Grenola Limestone (Lower Permian) in Southern Kansas, Bulletin 130, Part 3, 50¢, 1958.

History of Cretaceous Structural Studies in Kansas, Bulletin 130, Part 5, 25¢, 1958.

The Mineral Industry in Kansas in 1957, Bulletin 130, Part 6, 50¢, 1958.

Geology and Ground-Water Hydrology of the Ingalls Area, Kansas, Bulletin 132, $1, 1958.

Geology and Ground-Water Resources of Kansas River Valley Between Wamego and Topeka Vicinity, Bulletin 135, $1, 1959.

Geology and Ground-Water Resources of Mitchell County, Kansas, Bulletin 140, $1, 1959.

Preliminary Regional Structural Contour Map on Top of the Stone Corral Formation (Permian) in Kansas, Oil and Gas Investigations No. 17, Map, 50¢, 1958.

Preliminary Regional Structural Contour Map on Top of the Lansing Group (Pennsylvanian) in Kansas, Oil and Gas Investigations No. 19, 50¢, 1958.

Maine

Order From:
State Geologist
Dept. of Economic Development
State Office Bldg.
Augusta, Maine

Mineral Resources of Maine, Reference Map, 25¢, 1959.

First Supplement to Bibliography on Maine Geology 1836-1957, supplement 1836-1959, 10¢, 1959.

Maryland

Order From:
Dept. of Geology, Mines, and Water Resources
The Johns Hopkins University
Baltimore 18, Md.

Water Resources of Carroll and Frederick Counties, Bulletin 22, $3, 1958.

Missouri

Order From:
Missouri School of Mines
Rolla, Mo.

Spilitic Rocks and Mineral Deposits, Technical Series No. 96, gratis, 1958.

North Dakota

Order From:
Wilson M. Laird
State Geologist
Grand Forks, N. D.

Twenty-Ninth Biennial Report, 1956, gratis. **The Geology of North Dakota**, Bulletin 31, 75¢, 1956.

Halite Deposits in North Dakota, Report of Investigations No. 28, $1, 1957.

Oregon

Order From:
Dept. of Geology and Mineral Industries
1069 State Office Bldg.
Portland 1, Ore.

Bibliography of Theses on Oregon Geology, Miscellaneous Paper No. 7, 50¢, 1959.

Tennessee

Order From:
Div. of Geology
Dept. of Conservation
G-5 State Office Bldg.
Nashville, Tenn.

The Zinc Industry of Tennessee, Information Circular No. 6, 25¢, 1958.

Structure of the Cumberland Plateau, Tennessee, Report of Investigation No. 8, 25¢ 1958.

Texas

Order From:
Bureau of Economic Geology
The University of Texas
University Station, Box 8022
Austin 12, Texas

Geology of the Pinto Canyon Area, Presidio County, Texas, Geologic Quadrangle Map No. 22, 75¢, 1958.

Symposium on Edwards Limestone in Central Texas, University of Texas Publication 5905, $5, 1959.

Internal Structure of the Grand Saline Salt Dome, Van Zandt County, Texas, Report of Investigations No. 38, $1, 1959.

Washington

Order From:
Washington Dept. of Conservation
335 General Administration Bldg.
Olympia, Wash.

The Mineral Industry of Washington, in 1957, Area Report B-62, gratis, available from Bureau of Mines, Div. of Mineral Industries, Region I, PO Box 492, Albany, Ore.

1958 Directory of Washington Mining Operations, Information Circular 28, by W. S. Moen, V. E. Livingston, Jr., and G. W. Thorsen, gratis.

Wyoming

Geological Survey
The University of Wyoming
Laramie, Wyo.

Proceedings of the Fifth Biennial Briquetting Conference, Information Circular No. 9, $3, 1958.

The Chemical Basis for Reactivity in Primary Tars, Miscellaneous Publications No. 11, gratis, 1958.

U. S. BUREAU OF MINES

Request free publications from:
Publications Distribution Section
U.S. Bureau of Mines
4800 Forbes Street
Pittsburgh 13, Pa.

IC 7858 Using Precast Reinforced-Concrete Sets in the Pioneer Tunnel of Great Northern Railway's Cascade Tunnel, King County, Wash.

IC 7868 Raising With a Suspended Work Cage at the Irene Shafts, Leadville, Colo.

Order From:
Publications Distribution Section
U. S. Bureau of Mines
Washington 25, D. C.

Mineral Trade Notes for September 1958, Special Supplement 55 to Vol. 47, No. 3. The Foreign Mineral Trade of the U.S.S.R. in 1956, gratis.

Mineral Trade Notes for January 1959, Special Supplement 56 to Vol. 48, No. 1, The Foreign Mineral Trade of the U.S.S.R. in 1957, gratis.

U. S. GEOLOGICAL SURVEY

Order From:
U.S. Geological Survey
Washington 25, D. C.

Circular 410 Probability analysis applied to a water-supply problem, gratis, 1959.

Circular 409 Water yield and reservoir storage in the United States, gratis, 1959.

Open-file Report available for inspection at the Interior Dept. Library, 18th and C. Sts., Washington 25, D. C.: **Mines Bureau Report on Tests of Hawaiian Bauxite.**

CANADA

Government Publications

Order From:
Queen's Printer
Ottawa, Ont.
Canada

Iron Mining Industry, 25¢, 1957.

Feldspar & Quartz Mining Industry, 25¢, 1957.

Organization of the Government of Canada, Cat. No. SP4-158, $2, 1958.

Report Concerning the Production, Distribution and Sale of Zinc Oxide, Cat. No. J53-58/3, 50¢.

Industrial Minerals of Newfoundland, Cat. No. M32-855, $2, 1958.

Zinc in Canada with Comments on World Conditions, Cat. No. M33-137, 50¢.

Flora of the Upper Cretaceous Nanaimo Group of Vancouver Island, British Columbia, Cat. No. M46-293, $4.

Order From:
Publications Distribution Office
Mines Branch
Dept. of Mines and Technical Surveys
Ottawa, Canada

Extensive Progress Being Made in High Temperature Technology, Information Circular IC 108, 10¢, 1958.

Direct Reduction of Iron Ore, Information Circular IC 109, 10¢, 1958.

Principal Mineral Areas, Map 900 A, 25¢.

Milling Plants in Canada, Metallic Ores, Mineral Resources Operators List 3, part 1, 25¢ 1958.

Mackenzie Basins in Canada, 1952-1953, Report 856, Water Survey Report No. 8, $1.

Iron Ore and Other Raw Material Sources for a Primary Iron and Steel Industry in Western, Canada, Mineral Information Bulletin MR 28, gratis, 1958.

Mineral Information Bulletin MR 29, Mineral Legislation 1958, 25¢, 1958.

Mineral Information Bulletin MR 30, Summary Review of Federal Taxation, 25¢, 1958.

Research Report R 24, Gamma-Ray Analysis of Atmospheric Dust Samples, 25¢, 1958.

Research Report R. 25, Determination of Kerosene Entrainment Losses in the Solvent Extraction of a Leach Liquor, 25¢, 1958.

Research Report R 27, The Composition and Microtexture of an Ulvospinel Magnetite Intergrowth, 25¢, 1958.

Research Report R 28, Effect on Reagent Consumption of Recycling Solutions in the Weak Acid Leaching of a Uranium Ore, 25¢, 1958.

Research Report R 29, Voltaic Cells in Fused Salts, Part V, 25¢, 1958.

Research Report R 31, Studies on the Separation of the Rare Earths from Thorium in Sulphate Solutions Using Cation Exchange Resins, 25¢, 1958.

Research Report R 32, Some Solubility Studies in the System Thorium Carbonate-Sodium Carbonate-Sodium Bicarbonate-Sodium Sulphate-Water, 25¢, 1958.

Research Report R 34, The Thorin Colorimetric Method For Thorium Determination, 25¢, 1958.

Information Circular IC 111, The Corrosion Resistance of Wrought Iron and Open-Hearth Steel, 25¢, 1958.

British Columbia

Order From:
The Deputy Minister of Mines
Victoria, B. C.
Canada

Annual Report of the Minister of Mines, 1957, gratis, 1958.

FOREIGN PUBLICATIONS

Belgium

Order From:
Service Geologique de Belgique
13, Rue Jenner
Bruxelles 4, Belgium

Carte Geologique de la Belgique, in color,

BOOKS

(Continued from page 477)

23¢ approx. (12 Fr.); black and white, 11¢ approx. (6 Fr.).

Carte Geologique de la Belgique, in 12 sheets, 75¢ each (40 Fr.) or $9.12 approx. for the set (480 Fr.).

Order From:

Librairie L'Edition Universelle
88 Rue Royale
Bruxelles, Belgium

Legende Generale de la Carte Geologique Detaille de la Belgique, 80 pp., 29¢ approx. (15 Fr.).

Carte Generale Des Mines: coal fields of Liege; coal fields of Charleroi; coal fields of Mons; 100 Francs each, Belgian currency.

British Commonwealth

Order From:

Mineral Resources Division
Overseas Geological Surveys
Commonwealth Inst. Bldg.
London, S.W.7.

The East African Rift System, Bulletin Supplement 1, by F. Dixey, approx. $1.05 (7s.6d.), 1956.

Colonial Geological Surveys 1947-1956, Bulletin Supplement 2, by F. Dixey, approx. $1.50 (10s.7d.), 1957.

Statistical Summary of the Mineral Industry, 1951-1956, an annual review of production, export, and import statistics of the world, approx. $4 (28s.4d.), 1958.

Gypsum and Anhydrite, Mineral Monograph, by A. W. Groves, approx. $1.05 (7s.6d.), 1958.

The Lead-Zinc-Vanadium Deposits at Broken Hill, Northern Rhodesia, by J. H. Taylor, approx. 20¢ (1s.6d.), 1955.

Order From:

H. M. Stationery Office
York House, Kingsway, W.C.2
P.O. Box 569, S.E.1

or

British Information Services
45 Rockefeller Plaza
New York 20, N.Y.

Geology of the Midlothian Coalfield, Memoir, by W. Tulloch and H. S. Walton, *Geological Survey of Great Britain,* approx. $3.10 (21s. 10d.), 1958.

Geological Survey of Great Britain and the Museum of Practical Geology, Summary of Progress for 1957, approx. 75¢ (5s.5d.).

The Efficient Use of Fuel, Ministry of Power, 2nd edition, approx. $6.30 (35s.), 1958.

Classification of the Coal Measures of South Wales, Bulletin 13, II, approx. $1.15, 1957.

The Economic Geology of the Stirling and Clackmannan Coalfield, Scotland, Coalfield Paper No. 1, approx. $1, 1956.

The Metalliferous Mining Region of South-West England, Vols. I and II, approx. $14.70 (105s.), 1956.

Notes on Grants Awarded by the Dept. of Scientific and Industrial Research to Research Workers and Students, approx. 15¢ (11d.), 1956.

Science and Technology in Western Germany, approx. 75¢ (4s.2d.), 1955.

Czechoslovakia

Chemical Analyses of Mineral Raw Materials No. 13, Waters, 85¢ approx. (Kcs 6,90), Publishing House of the Slovak Academy of Sciences, Klemensova 27, Bratislava, Czechoslovakia.

France

Order From:

Librairie Polytechnique
Ch. Beranger
15, rue des Saints-Peres
Paris

Carte Geologique de la France, 4th edition 1955, approx. $6, (3000 Francs).

Recherche et Etude Economique des Gites Metallifères, approx. $17.80 (8900 Francs).

Determination Microscopique des Mineraux des Sables, approx. $3.50 (1700 Francs).

Ghana

Order From:

The Director of Geological Survey
P.O. Box 98
Saltpoad, Ghana

The Geology of ¼° Field Sheet No. 32, approx. $1.35 (7s.6d.), 1958.

Germany

Nachschlagewerk fuer die Montanunion (European Coal and Steel Community), *C. L. Krueger,* Westenhellweg 9, Dortmund, approx. $7.15 (30 German marks).

Malaya

Order From:

Director, Geological Survey
Federation of Malaya
P.O. Box 1015, IPOH

Account of the Geology and Mining Industries of South Selangor and Negri Sembilan, $3.50 in Malayan currency, 1922.

The Geology and Mineral Resources of the neighborhood of Chegar Perah and Merapoh, Pahang, Geological Survey Memoir No. 4, $6.00 in Malayan currency, 1950.

The Geology and Mineral Resources of the Fraser's Hill area, Selangor, Perak and Pahang, Geological Survey Memoir No. 6, $6.00 Malayan currency, 1951.

The Geology and Mineral Resources of the Neighborhood of Kuantan, Pahang, Geological Survey Memoir No. 6, $6.00 Malayan currency, 1952.

The Geology and Mineral Resources of the neighborhood of Kuala Selangor and Rasa, Selangor, Federation of Malaya, Geological Survey Memoir No. 7, $6.00 Malayan currency, 1953.

Annual Reports of the Geological Survey Dept.: 1947, $1.50; 1948, $2.00; 1949, $2.00, Malayan currency.

Order From:

Ministry of Natural Resources
Department of Mines
Federation of Malaya

Ilmenite from Alluvial Deposits in Malaya, Bulletin No. 1, $2.00 (Malayan) 1957.

Tantalum/Niobium Minerals in Malaya, Bulletin No. 2, $2.50, (Malayan) 1957.

A Note on An Occurrence of Stannite in Malaya, Bulletin No. 3, $1.50 (Malayan), 1957.

Flotation Methods for the Removal of Sulphides from Tin Ores in Malaya, Bulletin No. 4, $1.50 (Malayan), 1957.

Airborne Magnetometer and Scintillation Counter Survey, Area I, Economic Bulletin 1.1, $5 (Malayan), 1958.

ABSTRACTS

In This Issue: *The following abstracts of papers in this issue are reproduced for the convenience of members who wish to maintain a reference card file and for the use of librarians and abstracting services. At the end of each abstract is given the proper permanent reference to the paper for bibliography purposes.*

Photogrammetric Methods and the Open Pit Mine by *A. Tremari and Paul I. Eimon*—Photogrammetric methods make it possible to produce: accurate periodic maps; cross sections for computations; prints for geologic interpretation; an accurate record of conditions at a given date; and improved surveying efficiency. Choice of aerial or terrestrial photography depends primarily on physical layout of mine plus map requirements. Such methods are now in use by German coal mines at Bingham Canyon, Utah, and by TVA for coal stockpile inventory. **Ref.: MINING ENGINEERING, May 1959, p. 497.**

South African Mining—A Time to Invest? by *Howard S. Strouth*—Personal opinions and firsthand information on politics, economic atmosphere, and mining opportunities in the Union of South Africa. Specifics are included on labor, transportation and harbor facilities, availability of properties. Added are brief commentaries on ferrous ores, chrome, uranium and gold, coal and energy, pegmatites in general, copper, and other minerals. **Ref.: MINING ENGINEERING, May 1959, p. 502.**

Designing Ore-Treatment Pilot Plants by *Robert D. Macdonald* and *Frank M. Stephens, Jr.*—As processes for handling low-grade or complex ore become more complicated and as new methods are found, the need arises for more complete and detailed pilot-plant studies to protect the capital investment required for a full-scale plant. The authors consider the factors: plant feed, location, size, equipment availability, alternate flows, auxiliary space, material balance, heat balance, layout, flowsheet, piping, control and instrumentation, costs, reagents, manpower, maintenance, safety, drawings, collecting adequate data, coordination, providing for adequate chemical analyses, interpreting and reporting data, and translating results to commercial scale. **Ref. MINING ENGINEERING, May 1959, pp. 509.**

Railroad Car-Dumper Coal Sampling by *W. R. Reichenstein* and *Armand Bur*—The authors hold that coal samples can only retain mine identity if they are taken during car dumping. An effective method of obtaining representative samples is given with descriptions of installed car-dumper sampling systems and analysis of results compared with hand and mechanical belt sampling. **Ref.: MINING ENGINEERING, May 1959, p. 506.**

Economic History of the Lake Superior Iron District by *R. S. Archibald* (TP 4800A)—Accompanying this report is a chart showing estimated requirements of iron ore in the U. S. over a period of 30 years beginning with 1957, and the sources from which such requirements will be met. The chart shows a continued and rapid growth of the steel industry in the U. S. It will be noted that underground production from the Lake Superior District continues almost in a horizontal line over this period. There is rapid depletion of the Minnesota open pit direct-shipping and gravity concentrates, and a rapid increase in production of taconite concentrates. Cost per unit of plants for producing taconite concentrates is very high, and it is doubtful that taconite production will increase as rapidly as shown on the chart. The balance of reserves required for the steel industry will have to come from Canadian and other foreign imports. **Ref.: (MINING ENGINEERING, May 1959) AIME Trans., 1959, vol. 214, p. 513.**

Gyro-Compass Surveys Underground Workings and Boreholes by *Eugene P. Pfleider* and *Otto Rellensmann* (TP 4798A)—During the past ten years Autonetics in California has developed a comparatively lightweight (100 lb) gyro-theodolite, and the Institute for Mine Surveying at Clausthal Mining Academy in Germany has developed an instrument that is accurate to within 20 to 30 in. of arc. Concurrently, Minneapolis-Honeywell has produced a gyro the size of a salt shaker, that weighs less than 0.5 lb and compares favorably in performance with the 50-lb gyros of conventional design. This unit, designed for missile guidance, should be adaptable for surveying small boreholes. Given the proper interest and approach from the engineering fraternity, excellent gyro-compasses could probably be available for accurate underground survey work at nominal cost within the next three years. **Ref.: (MINING ENGINEERING, May 1959) AIME Trans., 1959, vol. 214, p. 521.**

Midnite Mine: Geology and Development by *R. F. Sheldon* (TP 4796I)—Uranium orebodies of the Midnite mine, which are localized along the contact between granitic intrusive rocks and metamorphosed sedimentary rocks, constitute the largest known deposit of this type in America. It is anomalous that the site of the initial discoveries still represents the only appreciable deposit of its kind found in the surrounding region, despite extensive prospecting of the contact zone for many miles. **Ref.: (MINING ENGINEERING May 1959) AIME Trans., 1959, vol. 214, p. 531.**

Recent Developments in Pebble Milling by *Bunting S. Crocker* (TP 4801B)—The purpose of this paper is to focus attention on the benefits to be derived from the use of screened ore as a grinding media. The subject has been reviewed each year for the past five years, and each year statements have been made which indicate that the reviewers are not thoroughly familiar with the use and potentialities of this practice. By means of this paper, it is hoped that some of these misunderstandings can be corrected so that more plants can take advantage of this cheap and efficient method of comminution. **Ref.: (MINING ENGINEERING May 1959) AIME Trans., 1959, vol. 214, p. 527.**

Application of Electron Diffraction and Electron Microscopy to Mineral Engineering by *J. E. Lawver* and *G. L. Samsel* (TP 4803B)—The electron microscope and electron diffraction camera are particularly useful instruments in the study of surfaces. The following examples of electron micrographs and electron diffraction patterns have been valuable guides in mineral dressing research at International Minerals and Chemical Corp. **Ref.: (MINING ENGINEERING May 1959) AIME Trans., 1959, vol. 214, p. 535.**

MANUFACTURERS NEWS

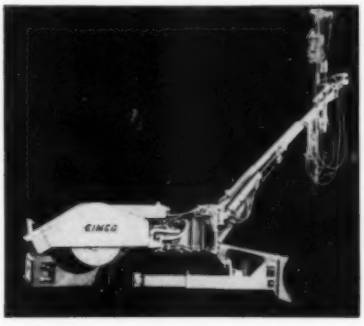
NEWS / EQUIPMENT / CATALOGS

Flexible Sheet Explosive

Punch circular holes in sheet steel, harden dipper teeth, cut a steel plate in half—all these operations are possible with a minimum of effort thanks to a new flexible sheet explosive by the Explosives Dept. of *E. I. Du Pont de Nemours & Co.* Tough, waterproof EL-506 sheet is a combination of PETN and other ingredients supplied in size 10x20 in. And the explosive is easy to apply. After the sheet is cut (a fixed-blade knife does the job), an adhesive is applied to the surface and the explosive put in place. An electric blasting cap is recommended for detonating the material. Manganese steel parts such as dipper teeth can be pre-hardened with the new agent, and shaped charges for better cutting of plates are also possible. A new brochure from Du Pont tells how. **Circle No. 1.**

Electric Dozer-Roof Bolter

Eimco Corp. has begun production of a new electric dozer and mine roof bolter, designated model 637. Shown here with hydraulically-operated bolting attachment, unit operates on a-c or d-c motors which



drive pumps providing hydraulic power to tracks, dozer, drill boom, and cable reel. Traction control valve gives three speeds forward, three reverse. Boom folds back, permits dozing in less than 5 ft of headroom. **Circle No. 2.**

Flocculating Agent

National Hydrochemical Corp. has developed Hydrochem 66, a flocculating agent with the ability to reduce zeta potential of suspended solids to zero, increasing flocculation of micron-size slimes. Of special interest to iron beneficiation plants, nickel refineries, coal operations, the agent is based on the polycarboxylic sugar derivates found in the agava sisillana. Data and free samples are offered. **Circle No. 3.**

Stripa Separation Process

Detailed data on the sink-float process of iron ore separation developed at the Stripa mine in Sweden is available from *Canadian Vickers Ltd.* which has been licensed to manufacture Stripa plants. One advantage of the process is that ore

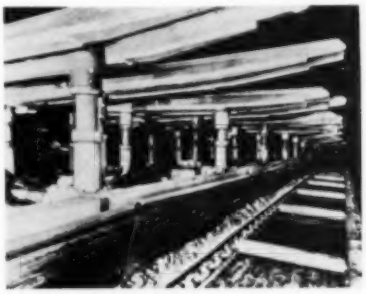
minerals themselves can be used as solids in the medium used to eliminate gangue, and purchase of ferrosilicon, galena, etc. is unnecessary. Vickers' new pilot plant is shown in above photo. **Circle No. 4.**

Safety Backup Horn

An electronic horn that emits a sure signal from vehicles moving in reverse is available from *Atkinson Dynamics Co.* The Dynalarm horn operates automatically, is permanently sealed, and is easily installed. With it, backup safety worries can be eliminated. **Circle No. 5.**

Roof Supports

Dowty Mining Eqpt. Ltd. of England has a self-advancing hydraulic roof support system called Roofmaster, which has cut labor requirements in longwall mining and greatly increased output. Only two men are needed for the continuous operation of 200 support frames. **Circle No. 6.**



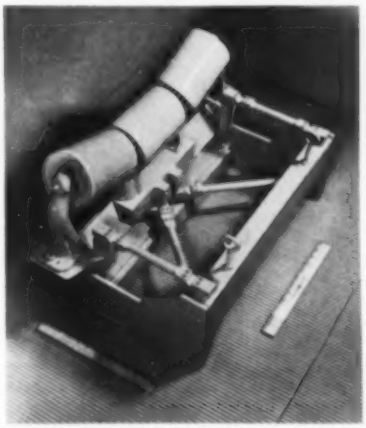
Earthmovers

International Harvester Co. has introduced three new earthmovers boasting increased capacities and power and higher speeds. New machines are: 27-cu yd model 495

Paywagon (shown); 24-cu yd model 495 Payscraper; and 24-cu yd model 295 Payscraper. Paywagon's power-opened clamshell doors afford positive, controlled dumping. **Circle No. 7.**

Electronic Conveyor Scale

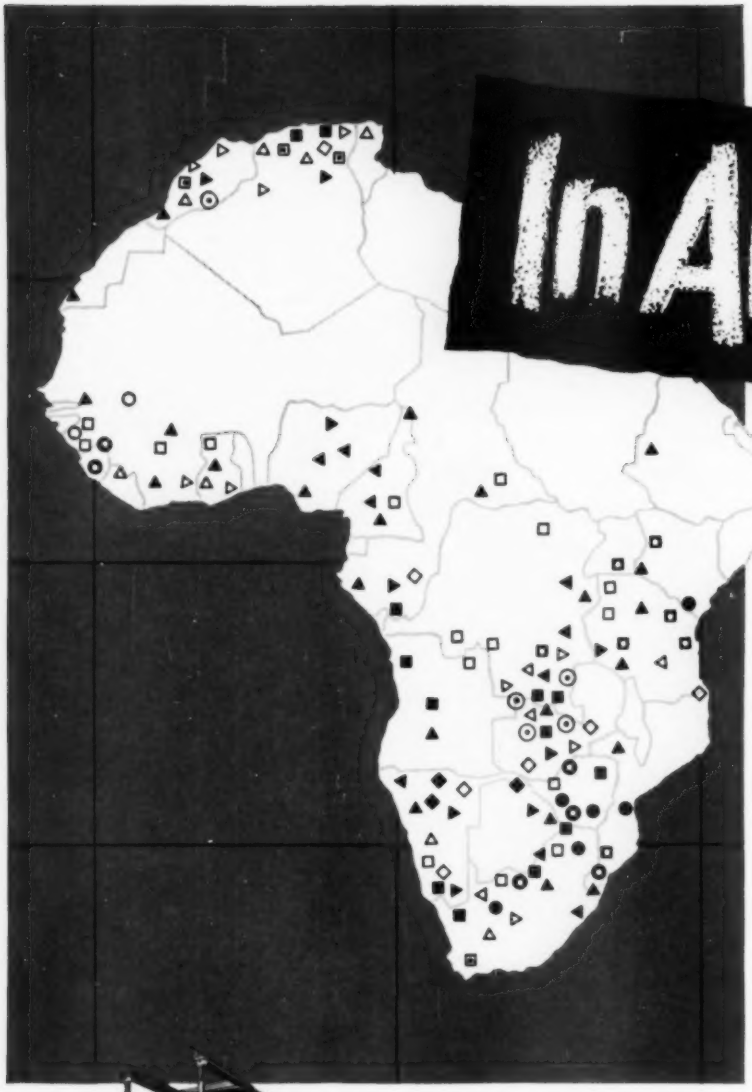
Bell Automation Corp. has a new continuously totalizing scale which easily mounts between idlers of any standard belt conveyor from 14 to 72 in. in width. Simple but rugged, the scale utilizes an electrical transducer to convert instantaneous load weight into proportional voltages



for continuous integration and digital display. Wishbone assembly permits only vertical weight displacements to be measured. **Circle No. 8.**

News & Notes

Atlas Copco has established a subsidiary in Lisbon, Portugal, and will supply compressors and air-powered tools . . . . Information on a construction equipment mechanic's training course can be obtained by writing direct to Greer Technical Institute, Wilmington, Ill. . . . A division of *Universal Marion Corp.* is constructing a new stripping shovel of 65-cu yd capacity and 165-ft boom . . . . *Texas Instruments Inc.* has formed a GeoSciences & Instrumentation Div.



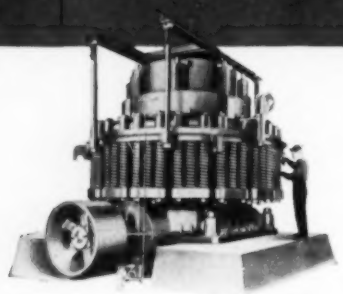
. . . SYMONS® CONE CRUSHERS

used for efficient reduction of ores and minerals

(Partial list of Africa's ores and minerals. Symbols indicate location of important deposits.)

● ASBESTOS	▶ LEAD
○ BAUXITE	▷ MANGANESE
◘ CHROMIUM	◘ MICA
⊙ COBALT	▣ PHOSPHATES
■ COPPER	◀ TIN
□ DIAMONDS	◁ URANIUM
▲ GOLD	◆ VANADIUM
△ IRON	◇ ZINC

. . . as well as aggregates, cement rock, gravel, etc., for the construction industry.



SYMONS CONE CRUSHERS
. . . The machines that revolutionized crushing practice . . . **are built in a wide range of sizes, for capacities to over 900 tons per hour. Write for descriptive literature.**

In all of the great ore and mineral operations around the world . . . there has been no record to equal the performance of Symons Cone Crushers in consistently and efficiently producing great quantities of finely crushed product at low cost.

In Africa, hundreds of Symons Cones are used by leading producers of most of the ores and minerals found in this giant continent. As an indication of its mineral wealth, it is significant to note that Africa produces almost 75% of the world's cobalt, 65% of its gold, 50% of its antimony, 33% of its manganese, chrome and phosphates, 25% of its copper, 15% of its lead and tin, a large part of its uranium and practically all of its diamonds.

The use of Symons Cone Crushers in Africa is another example of the way in which these efficient crushers serve the mining and mineral processing industries of the world.

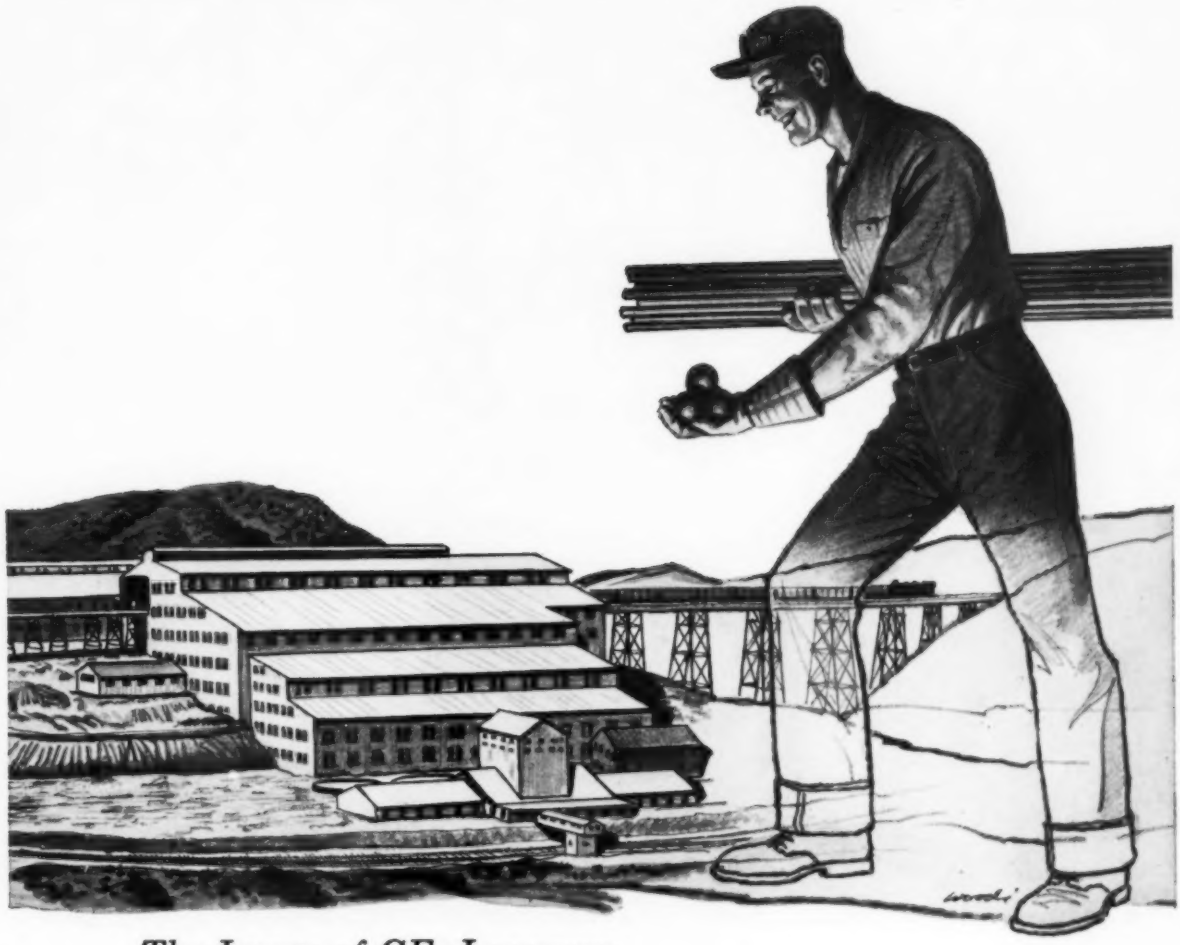
NORDBERG MFG. CO., Milwaukee 1, Wisconsin

©1959, N. M. CO. M159

SYMONS . . . a registered Nordberg trademark known throughout the world.

NORDBERG

ATLANTA • CLEVELAND • DALLAS • DULUTH • HOUSTON • KANSAS CITY • MINNEAPOLIS • NEW ORLEANS • NEW YORK • ST LOUIS
SAN FRANCISCO • TAMPA • WASHINGTON • TORONTO • VANCOUVER • JOHANNESBURG • LONDON • MEXICO, D. F.



The Image of CF&I assures

quality steel Mining Products

This Image—the CF&I giant—stands for hundreds of dependable steel products used by many industries. And the CF&I name is prominent in the mining industry for such top-grade products as grinding balls and grinding rods.

For instance, the special analysis, hot-forged steel used in CF&I Grinding Balls gives uniform wearing qualities... high impact and abrasion resistance... maximum grinding efficiency.

CF&I Grinding Rods are hot-rolled from steel of special analysis, determined through years of experience to provide a hardness for high wear resistance, yet with a toughness to exclude bending or premature breakage. All rods are machine-straightened and their ends cut square so that they will freely rotate in the rod mill for better grinding.

We suggest you contact the nearest CF&I sales representative. He'll be glad to discuss your grinding problems with you, or give you complete information on all CF&I Mining Products.

OTHER CF&I STEEL PRODUCTS FOR THE MINING INDUSTRY

CF&I Grader Blades • CF&I Industrial Screens • CF&I Mine Rail and Accessories
CF&I-Wickwire Rope • CF&I Rock Bolts and Realock Metallic Fabric

CF&I STEEL

MINING PRODUCTS

THE COLORADO FUEL AND IRON CORPORATION

In the West: **THE COLORADO FUEL AND IRON CORPORATION**—Albuquerque · Amarillo · Billings · Boise · Butte · Denver · El Paso · Farmington · Ft. Worth · Houston · Kansas City · Lincoln · Los Angeles · Oakland · Oklahoma City · Phoenix · Portland · Pueblo · Salt Lake City · San Francisco · San Leandro · Seattle · Spokane · Wichita

In the East: **WICKWIRE SPENCER STEEL DIVISION**—Atlanta · Boston · Buffalo · Chicago · Detroit · New Orleans · New York · Philadelphia 6625

"Our Ford F-800's, pulling 20-ton payloads, give us mighty good service!"

says R. Dillard Teer, Vice President
Nello L. Teer Co., Durham, N. Carolina

"We operate about 115 Ford Trucks ranging in size from ½-ton pickups to Tilt Cab Tandem tractors. We believe in carefully fitting the truck to the job to be done and usually stay within the manufacturer's recommended ratings. We make an exception to this rule with our Ford F-800's, pulling 20-ton loads in aluminum trailer dumps to our quarry and crushing setup at Durham, North Carolina. These units are carrying the maximum legal limit and give us mighty good service!

"We haven't traded any trucks in about 6 years. It just happens that our company has been growing so rapidly that when we buy a new truck, usually an F-800, I put it under one of our trailer dumps. Then I'll take the old truck, lengthen the chassis, and make a grease outfit or a water wagon out of it. I would say out of over a hundred Ford units in the past 7 or 8 years, we have gotten rid of only a dozen altogether—and some of these were wrecked or burned.

"Another reason we use Fords is that this business is rough on trucks, so parts availability is very important. Our experience over the years with Ford as compared to Ford competitors has been definitely in favor of Ford on parts."

NOW! CERTIFIED PROOF!

FORD TRUCKS COST LESS

'59 Ford Pickups beat average mileage of other leading makes by 25.2% in Economy Showdown U.S.A.

Here at last is certified proof of the differences in gas mileage between six-cylinder pickups . . . evidence that you can use in your operation.

It was compiled by America's foremost independent automotive research firm after testing 1959 six-cylinder, ½-ton pickups of the six leading makes. All trucks were bought from dealers—just as you would.

The tests paralleled every kind of driving – high speeds and low, open highways and city traffic, even door-to-door delivery. And in every test, '59 Ford Sixes delivered more miles per gallon than any other make. Here are the actual percentages:

'59 FORD PICKUP SIXES GAVE

42.6% better mileage than make "D"
31.1% better mileage than make "I"
25.2% better mileage than make "C"
22.0% better mileage than make "S"
9.6% better mileage than make "G"

Taken together, Ford got 25.2% more miles per gallon than the average of all other leading pickups!

What's the secret of Ford's economy? First, of all pickup sixes, only the Ford Six has modern Short Stroke design which reduces friction and requires less fuel. Second, to this modern engine, Ford has added a new economy carburetor to meter fuel more precisely in both high- and low-speed ranges.

See your Ford Dealer for the full report of Economy Showdown U.S.A. and get the whole story firsthand.

All tests conducted and results
CERTIFIED
by America's foremost independent automotive research organization*
***NAME AVAILABLE ON REQUEST**
Send inquiry to P.O. Box 2687, Ford Division
Ford Motor Co., Detroit 31, Michigan

Now! During Dividend Days at your Ford Dealer's...Go *FORD*-ward for Savings

Huge fan makes mine its own air conditioner!

Stainless steel prevents failure of fan blades in damp corrosive atmosphere

Warms air in winter! Cools air in summer!

That's how the system diagramed at the right improves working conditions in Inco-Canada's big Frood-Stobie mine.

In winter, the fan drives frigid outside air through sprayed water in two tremendous stopes at the 300- and 500-foot levels. The water freezes... gives up its heat to warm the air.

In the summer, the fan drives warm outside air over the glacier-like accumulation of ice formed during the winter. As the ice melts, it extracts heat from the air. Miners work in comfort year 'round.

It's all done with one 750,000 cu. ft./min. fan.

This big, 16½-foot fan operates continuously day-in, day-out in all weather. And that outside air it handles contains dust and traces of corrosive sulphur dioxide.

To meet these conditions the 12 blades of this fan are stainless steel.

Stainless steel insures long blade life

Nickel-containing stainless steel has the resistance to corrosion, erosion and fatigue called for in mine and mine building air-conditioning systems and in other mine applications. It gives you extra strength and toughness, too. And it's easy to fabricate.

How it works

Consider stainless steel when you need long, reliable equipment performance and extra strength.

The International Nickel Company, Inc.
67 Wall Street New York 5, N. Y.

INCO NICKEL

NICKEL ALLOYS PERFORM BETTER, LONGER

Wabush Contract Awarded

A contract to design and construct an iron ore concentration pilot plant to be built at Wabush Lake, Labrador, has been awarded to Kaiser Engineers' Canadian subsidiary, Henry J. Kaiser Co. (Canada) Ltd., by Wabush Iron Co. Ltd. of Cleveland. Plant will be located just inside the Labrador border, east of Mount Wright.

Copper Worry—Government to Market Excess Metal?

Because the Government's copper stockpile has exceeded the needed level, the Office of Civil and Defense Mobilization has been considering disposal of up to 128,000 tons of the red metal. The possible sale has brought disturbances in the more volatile segments of the copper market, despite the Government's assurance that sales, if any, would be made in small quantity and spread over a long period of time. The market has been sensitive to many influences lately since output has been greatly increased to meet heavier consumer demand, and upsets could force another price downturn. Barring strikes, metal appears adequate to meet needs, but custom smelters recently raised their prices to 32½¢ a pound because scrap supplies have been low. Primary producers continue to quote 31½¢ and cite good demand.

Airborne Geological Survey of Northern Ontario

Sixty thousand square miles of Canada will be covered by an airborne magnetic survey to be made by Ontario's Department of Mines in conjunction with Canada's federal government. The area to be surveyed is north of the Canadian National cross-Canada rail line between Nakina-Armstrong and Sioux Lookout, north of Lake Superior. Employing two aircraft, the survey will take about six months and cover 120,000 survey miles. The search will produce some 80 miles of punched tape which will then be fed into a Datatron computer for compilation. The result will be 160 individual map sheets which will be made available to mining and exploration companies to aid in the search for economic mineral deposits.

Lead-Zinc Stabilization Act Proposed

Legislation to supplant the import quotas imposed in the fall of 1958 has been proposed in three similar Congressional bills. Minimum domestic prices for lead and zinc, under terms of the legislation, would be held to 15½¢ and 13½¢ a pound, respectively. Also, the Secretary of Commerce, by import quotas decided upon in each quarter, would control the amount of metal permissible to keep up these floor prices.

Asarco Cuts Back to Curb World Metal Surplus

Because output of lead and zinc is "well in excess of demand, American Smelting & Refining Co. is making drastic new slashes in output. Properties and partly-owned operations in Australia, Canada, Mexico, and Peru will be affected. Beginning July 1, Mount Isa Mines Ltd. will cut its Australian output to about a third of capacity and is stockpiling about half its concentrate production. The Buchans mine in Newfoundland will cut output 10 pct from the 1958 level on June 1. Company management in Mexico and Peru has been instructed to cut output where possible. Five of the seven Asarco properties in the U. S. have already been closed and no further domestic curtailments have been planned. In announcing the new cutbacks, J. D. MacKenzie, Asarco chairman and president, declared, "Most of the world's production of lead and zinc

is either on a break-even basis or is actually being produced at a loss. Under the circumstances, curtailment of production to a level in line with consumption is the only means by which a sounder price structure can be achieved." . . . The price of lead has been raised a half cent by one of the custom smelters following a shortage of lead scrap and some pickup in consumer demand. Zinc demand continues moderate.

National Mine Safety Winners Announced

Bronze trophies are being awarded to the six 1958 winners of the National Safety Competition conducted by the U. S. Bureau of Mines. Winners receive a Sentinels of Safety trophy from *The Explosives Engineer* and are granted the privilege of flying a green and white award flag over mine or quarry. Competing mines and quarries numbered 675, a new high in total entrants in the 34-year-old competition. Winners for 1958 are:

Anthracite Underground Mine
Germantown Colliery
Raven Run Co.
Centralia, Pa.

Bituminous Coal Underground Mine
No. 14 Mine
U. S. Steel Corp.
Gary, W. Va.

Metal Underground Mine
Pioneer Mine
Oliver Iron Mining Co.
Ely, Minn.

Nonmetallic Underground Mine
Grand Rapids Mine
Bestwall Gypsum Co.
Grand Rapids, Mich.

Open Pit Mine
Erie Commercial Mine
Pickands Mather & Co.
Hoyt Lakes, Minn.

Quarry
Thornton Quarry
Material Service Corp.
Thornton, Ill.

Every employe of the winning operations receives an individual certificate from USBM for his part in winning the competition. Certificates of Achievement are awarded also to each mine and quarry whose position in the contest was among the first four in its respective group.

Mesabi Sues for Alleged Damages, Wants to Recover Stock

Mesabi Iron Co. has filed a suit against Armco Steel Corp. and Republic Steel Corp., each a 50-pct owner of Reserve Mining Co., to seek $67.5 million in damages, under antitrust laws, on the ground that Reserve sells taconite pellets, produced from Mesabi property by Reserve, to the two steel companies without competitive bidding. Mesabi has also asked that Republic and Armco be forced to give up control of Reserve, and is aiming at recovering 148,700 Mesabi shares owned by Reserve.

A Top Anthracite Producer Quits Coal

In order to cut losses resulting from hard coal operations, Lehigh Valley Industries, a major producer, has leased its active mining properties to another company. Lehigh will further diversify, since other of its present businesses are profitable, but all working Lehigh hard coal mines have been leased to Pagnotti Coal Co.

Sixtieth Anniversary for Asarco

American Smelting & Refining Co. celebrated the 60th Anniversary of its founding on April 4, 1959. The company reports 4849 employes have been with the company for 25 years or more.

This impressive installation at Kiruna, Sweden, demonstrates a major benefit of ASEA Multi-Rope Friction Hoists: *low initial installation cost.*

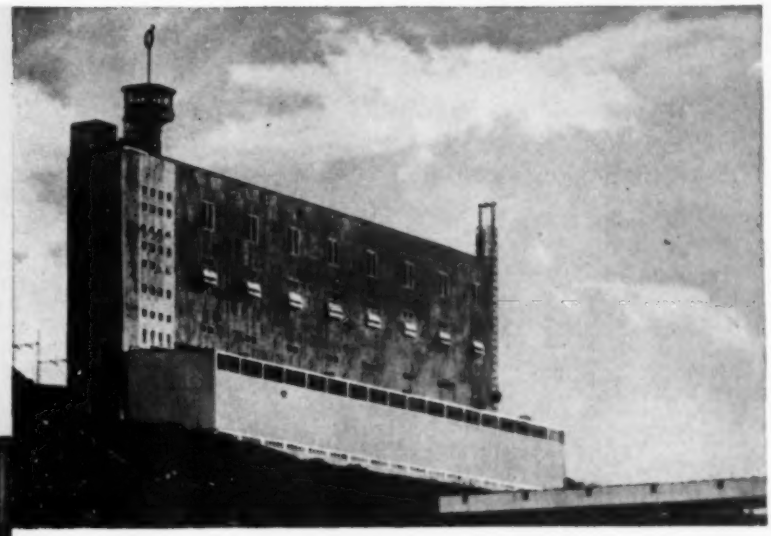
Each of these ASEA Hoists has a skipload of 22 tons and is designed for a depth of 1500 feet, maximum speed 2200 feet per minute.

At Kiruna, as in mining operations throughout the world, ASEA Multi-Rope Hoists prove less costly to operate, safer, and they reduce rope wear.

In the U. S. these advantages may be seen in the ASEA installations of National Potash Co. and Cleveland-Cliffs Iron Ore Co.

9 HOISTS IN ONE HEAD FRAME

Total capacity: 4600 tons per hour



FULLY AUTOMATIC, the ASEA Hoists at Kiruna eliminate the employment of hoist men.
At U.S. wage rates, assuming two-shift operation, this would mean a saving of about $30,000 yearly for each hoist!

Write for illustrated literature on ASEA Multi-Rope Friction-Drive Mine Hoists.

ASEA

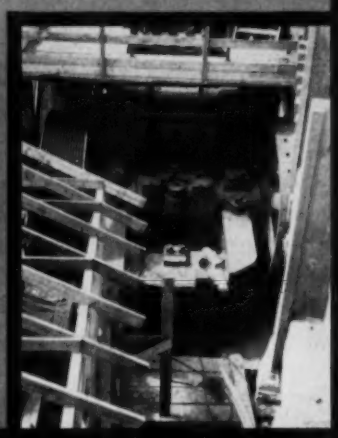
World pioneer in electrical products for industry

U. S. Sales and Service:

ASEA ELECTRIC, INC.

formerly ARos ELECTRIC, INC.

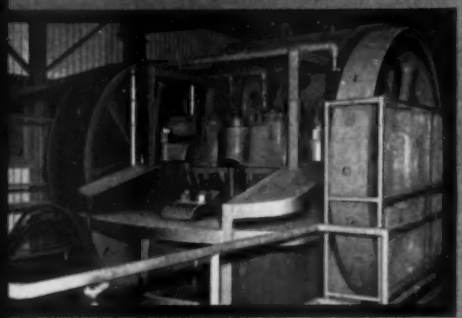
500 FIFTH AVENUE, NEW YORK 36, N. Y.

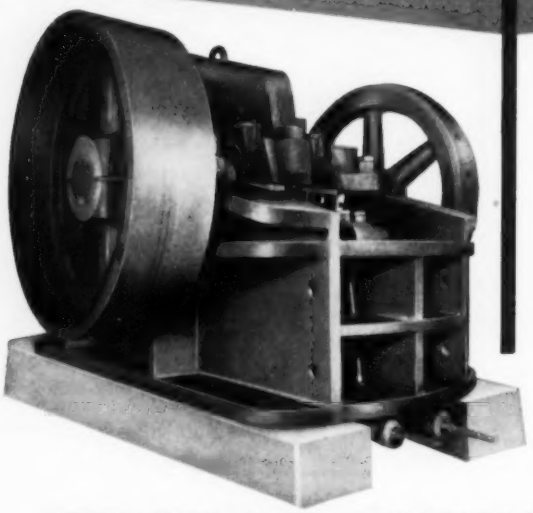


Traylor-made Type HB Jaw Crushers offer efficiency and economy

Shown above is a Traylor-made 48" x 60" Type HB Jaw Crusher in a stone crushing plant.

A Traylor-made 36" x 42" Type HB Jaw Crusher in a cement plant.





Many operators throughout the world experience daily the economy and rugged dependability of Traylor-made HB Jaw Crushers. Jaw plates are the famous curved type—the pitman shaft is made of annealed open hearth forged steel, light but of great strength. The swing jaw is made of cast steel of extra-heavy box section design to secure maximum strength. These are a few features of the Traylor HB Jaw Crusher. For additional information, write for bulletin No. 5105 today!

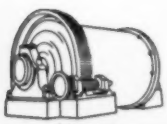
Traylor

TRAYLOR ENGINEERING & MFG. CO.

1153 MILL ST., ALLENTOWN, PA.

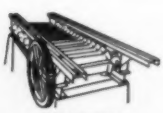
Sales Offices: New York — Chicago — San Francisco

Canadian Mfr.: Canadian Vickers, Ltd., Montreal, P.Q.



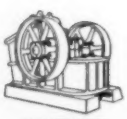
BALL MILLS

ROTARY KILNS



APRON FEEDERS

PRIMARY GYRATORY CRUSHERS



JAW CRUSHERS

SECONDARY GYRATORY CRUSHERS

Soviet Economic Challenge

The U. S. surpasses Russia by a substantial margin in the output of almost every item necessary to make capital goods and consumer goods, according to J. L. Singleton, vice president of the Industries Group of Allis-Chalmers.

Addressing the Fifth National Military-Industrial conference in Chicago last month, Singleton spoke on the subject, "What is the potential of the Soviet economic challenge?," and drew extensively from personal observations made during a visit to Russia last fall with a party of American utility and manufacturing executives.

Instead of a global *shooting* war, Singleton foresees eventual economic *warfare* to be directed chiefly toward the uncommitted, under-developed nations of the world. In this sense, it will be the U. S. and other free nations vs Russia and leading communist nations. He believes the free nations can win an economic war if they have "equal or superior economic resources."

Singleton approached his analysis of the potential of the Soviet economic challenge through a discussion of three important subtopics—power, resources, and people.

The fact that Russia needs more electric power is a matter of great concern to even the No. 1 Russian, Premier Khrushchev. This is spelled out in the premier's speech dedicating the Kuibyshev electric plant last August. Following are samples of remarks which reflect Soviet anxiety on the subject:

> "Reduction in construction time of the power plants will help to accelerate the solution of the basic economic problem—to reach and to overtake the advanced capitalistic countries in per capita productivity. Time here is of prime importance . . . The idea is to give preference to the steam power plants in order to gain time in competition with capitalism—to reach and to overtake the United States of America in per capita production."

Russia places its total generating capacity at 48 million kw, but Singleton feels the figure should be nearer 30 million because of *inconsistencies* in Russian reports he has had translated and analyzed. He said the total capacity for the U. S. by the end of 1958 was about 160 million kw.

Russia hopes to increase its power capability by 60 million kw by the end of 1965. Singleton thinks it may take them 17 years to reach that goal. He mentioned that the Russians seem to favor construction of steam-electric power plants rather than hydroelectric installations because of the shorter construction time involved.

Singleton also declared that most of Russia's natural resources are located in Siberia, so cold and far removed from industrial centers that it is difficult to utilize them efficiently.

According to Singleton, Russia is faced with a shortage of capital goods, another vital resource. The Soviet Union has a twofold problem here, he said. One is that Russia is doing a bare minimum of repair and replacement, with the result that she is getting along with much worn, old, and obsolete capital equipment. The second problem extends into the political sphere. While Russia could consume every capital item she produces, there will be pressures on her export capital goods to communist China and other Red countries.

"If Russia is to develop her own industries, then she cannot export sizeable amounts of capital goods," Singleton said.

With reference to human resources, the speaker noted that, historically, people will not remain frustrated indefinitely without improvement in living standards. For this reason it can be expected that an increasing share of the output in the communist countries will go for housing, transportation, communications, and the like. As living standards improve, people will demand more along this line.

Singleton said in conclusion, "I have every confidence that we can meet the Soviet economic challenge successfully, not only as a nation but, more importantly, in cooperation with the other committed Western nations."

New Topographic Maps

Small-scale maps of areas in the U.S. prepared by the Army Department have been published for general distribution by the Geological Survey, the Department of the Interior has announced. More than 340 maps in the series are available, and when complete the series will contain 469 maps.

The new series of maps at a scale of 1:250,000 was started several years ago to meet military requirements, but because they are of value elsewhere the Geological Survey has acquired the basic materials for use in preparing an edition to meet civilian needs.

In general, each quadrangle map of this series will cover one degree of latitude and two degrees of longitude or an average of more than 7000 sq miles. Names and general character of principal topographic and hydrographic features are shown, as well as villages, towns, roads, railroads, and other important culture. The contour interval used will vary from 50 to 500 ft depending upon terrain and the source data available.

A free index showing the area covered by each map can be obtained from the Map Information Office, Geological Survey, Washington 25, D. C.

Orders for maps, at 50¢ each, should be addressed to Geological Survey, Washington 25, D. C., or Geological Survey, Denver Federal Center, Denver, Colo., for maps of areas west of the Mississippi. Those for local areas are also available for sale over-the-counter but *not by mail* in Survey offices in the following locations: 602 Thomas Bldg., Dallas; 468 New Custom House, Denver; 504 Federal Bldg., Salt Lake City; 1031 Bartlett Bldg., Los Angeles; 724 Appraisers Bldg., San Francisco; and 204 Denali Bldg., Anchorage, Alaska.

African Uranium Costs, Revenue

Three South African uranium producers have made available cost-per-lb and revenue-per-lb

figures on their production. All three, however, are special situations and do not indicate the total picture of the South African uranium producers, many of which only produce uranium concentrates as a gold byproduct. In one of the mines under discussion, for instance, gold and uranium are two distinct operations; another must figure development payability on combined content of the two metals. The Randfontein mine, after crediting byproduct gold, runs a cost of about $10.25 per lb and sells at $13.20. E. Champ d'Or cost per lb is $12.65, including the rental it pays for the Randfontein plant, and revenue is $13.60. Freddies mine incurs a cost of $7 per lb, obtains revenue of $11.80.

Coal Industry Chiefs Ask U. S. Fuel Policy

Congress has under consideration a request for a new large-scale study of a major element in the nation's economy—the fuels of today and tomorrow and the industries dependent upon each.

Source of the request was the hard-hit coal industry, which presented case for a "coordinated policy on all fuel problems" that would insure the survival of industry to meet expanded national needs for all types of fuel products. Part of the news report from the National Coal Policy Conference follows:

> Making the case for the $5 billion coal industry and the two million Americans who earn their living directly or indirectly from it were a united group whose battles once held the nation's front pages. They included John L. Lewis and his United Mines Workers Union, coal producers, coal-carrying railroads, coal equipment manufacturers, and coal-burning utilities.
>
> A picture of coal needs three times the current reduced output, menaced by a danger that short-range problems may make it impossible to meet these needs, was painted by the group before a gathering of Congressmen and industrial leaders [in Washington during the last week in April]. The group has been organized as the "National Coal Policy Conference," to draw attention to the nation's fuel problems.
>
> The prediction of a national coal requirement of 1.2 billion tons annually by the year 2000, and an effective demand by 1975 for more than double the present output of 400 million tons, was made by Philip Sporn, president of American Electric Power Company. The utility's extensive use of coal as an energy-source has prompted an extensive projection of the industry's future needs . . . .
>
> Despite these optimistic predictions for an enlarged future domestic market for coal, spokesmen for the Conference found a danger that there would be no industry left to produce and distribute the fuel.
>
> George H. Love, chairman of the conference and head of the Consolidation Coal Company, cited restrictions placed on American exports by foreign countries which underwrite their own coal industries, as instruments of national policy. By contrast, he noted "periodic dumping" of fuels competitive with coal here, during short-term periods of surplus . . . . [He called for an unbiased study of the problem.]
>
> The alternative to a policy which enables all types of fuel producers to operate successfully is the destruction of railroads needed to carry coal to market, before the upturn in demand is reached, according to Howard E. Simpson, president of the Baltimore and Ohio Railroad. . . .
>
> "Drying up coal's share [in some cases, 70 pct] of the fuel market will seriously affect the railroad plant. Cars, locomotives and tracks supported primarily by coal traffic won't stand idle indefinitely until they are suddenly needed again." [Idle crews, skilled men, cannot be kept idle.] . . .
>
> Speaking for his industry as well as for his Mine Workers' Union membership, John L. Lewis warned of the immobilization of the nation in wartime if it has previously become completely dependent on ocean-shipped fuels.
>
> It is his conviction that coal productivity at 12 tons per man per day—in comparison with less than one ton per man abroad—has put the industry in position to survive to serve again in national emergency if Congress writes ground rules to "regulate competition among coal, oil, natural gas, and atomic power in a way fair to all."
>
> Coal industry objectives have been summarized by the Conference's executive director, Joseph E. Moody, as a national fuel policy which looks at energy resources as a whole, recognizing interrelationships between various fuels, drawing on each source for its most efficient and desirable distribution. Today national legislation and government policies treat fuels in separate compartments.
>
> "A national fuel policy refuses to countenance discriminatory competition, or the stifling of further development of a competitive fuel. It promotes long-term availability of a reliable energy supply at a reasonable cost by sensible policies of fuel conservation, development and distribution." . . . Congress [is called upon] to provide a forum in which all fuel suppliers can state their problems. . . .

Openings for Metallurgists

The Bureau of Mines has announced that applications are being accepted for positions of Metallurgist. These positions are located in some of the most modern and complete laboratories with excellent physical equipment for research and development. They involve work in diversified programs of national importance in the fields of mineral dressing, extractive and physical metallurgy. Most positions are with the Bureau in Minnesota, South Dakota, and Missouri, and starting salaries range from $374 to $734 a month. Additional information may be obtained from the Executive Secretary, Board of U. S. Civil Service Examiners, Bureau of Mines, Rolla, Mo.

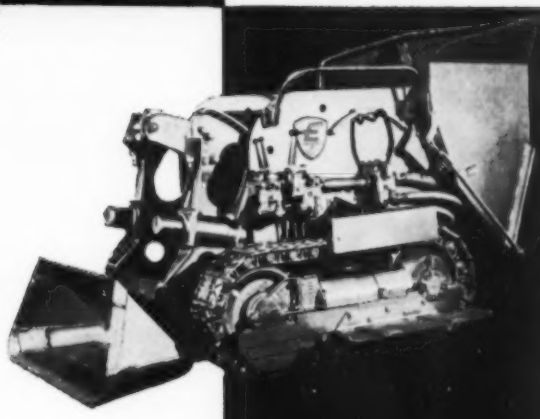
Notes from Underground

The New York Transit System's placard publication known as the *Subway Reader* lately has been greeting the wandering eyes of its readers with the following intelligence:

> One of the world's largest copper deposits is under the streets of New York. It consists of over 300 million lb of pure copper in the form of electric cables.

NEW from EIMCO

The Eimco 631 Hopper Loader



Crawler Mounted

Hopper Loader

with Greater Capacity

Latest addition to the famous 630 series of compressed air activated, crawler mounted equipment, with a greater hopper capacity of 45 cubic feet. With an additional 5 cubic feet carried in the bucket, a payload of three tons (50 cubic feet), can be easily handled. The 631 will also be available for AC operation.

The Eimco 631 is self-loading, capable of both loading and carrying material. It is the answer to many and varied problems of developing and production-loading in stopes, drawpoints and other such areas.

Features include special long tracks for maximum stability and ground contact area; a positive semi-automatic hold-device, for holding loaded bucket in carrying position; heavy-duty and removable hopper with full opening door; improved, heavier equalizer bar; new, improved trunnions and brackets and additional track rollers for a crawler base capable of easily carrying these heavier loads.

Contact the nearest sales office or write The Eimco Corporation, P.O. Box 300, Salt Lake City 10, Utah, for all details.

Another product of Eimco's

"ADVANCED ENGINEERING AND QUALITY CRAFTSMANSHIP SINCE 1884"

THE EIMCO CORPORATION

Export Offices Eimco Building, 51 - 52 South Street, New York 5, N. Y.

BRANCHES AND DEALERS IN PRINCIPAL CITIES THROUGHOUT THE WORLD

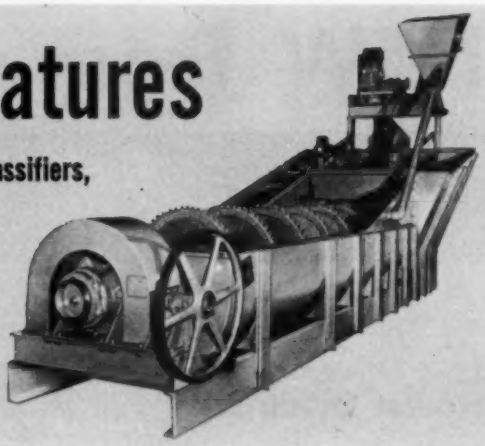
SALT LAKE CITY
UTAH

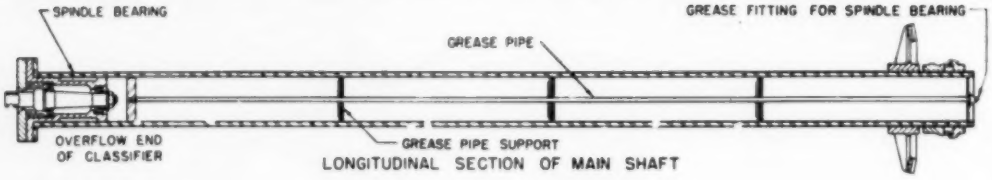
B-411

Exclusive Akins Features

which assure low-cost, trouble-free operation of classifiers, heavy media separators and densifiers

50 years of experience in the design, manufacture, and operating performance of spiral classifiers, heavy media separators and densifiers, has proven the importance of the exclusive mechanical features of the Akins machines... importance in terms of metallurgy, and in the economy of long, trouble-free operating life with minimum maintenance.





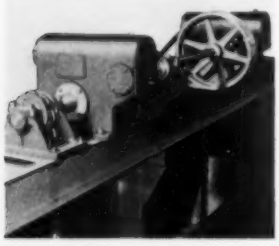
LONGITUDINAL SECTION OF MAIN SHAFT

SUBMERGED BEARING

The patented submerged bearing has proven its advantages of durability, trouble-free operation, and ease of maintenance.

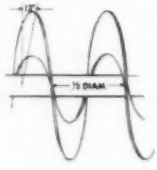
LUBRICATION

The submerged bearing is grease-gun lubricated through a pipe in the main shaft; thus the pipe is isolated from tank contents and protected against breakage. Grease fitting is at upper end of shaft for maximum convenience.



MECHANICAL LIFTING MECHANISM

The lifting device consists of chains, chain sprocket sheaves, and motor-driven or hand-operated reducer unit. Experience has proven this mechanical arrangement to be the most positive, with no possibility of slippage. Minimum maintenance. No packing glands or rods to become worn.



SPIRAL PITCH

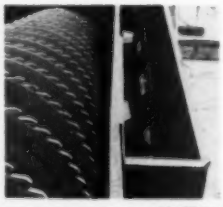
50 years of experience has shown that the half-diameter pitch gives maximum raking capacity and results in less slippage and less wear than advanced pitch spirals.

TANK SUPPORTS

Web beam substructure supports tank. There's no load to be carried by tank. This also reduces installation cost by eliminating need for extra sub-structures to support tank.

WEARING SHOES

Wearing shoes are made of various alloys, including Climax 42-A. Patented serrated wearing shoes are available for special applications. Special inner shoes are provided for heavy rake loads.



DRIVE

The bevel gear, V-belt drive has proven to be the most trouble-free and flexible. It permits mounting the motor, or motor-reducer, horizontally; and changing speeds quickly and inexpensively, by simply changing V-belt sheave ratio.

OVERFLOW BOX

An overflow box, with a pipe connection, is furnished as standard... requires only a single connection.

For complete information on Akins machines write for catalogs.

Manufacturing Division

THE MINE AND SMELTER SUPPLY CO.

DENVER 16	NEW YORK 17	SALT LAKE CITY 1	EL PASO
3800 RACE STREET	122 E. 42nd STREET	121 W. 2nd S.	P. O. BOX 1162

Licensed Manufacturers and Sales Agents in Canada, Australia, Sweden, England, South Africa
Sales Agents in Peru, Chile, Philippine Islands, Japan, New York City (for Continental Europe) and in principal cities of the United States.

MINING ENGINEERING STAFF

Editorial Director: Rixford A. Beals

Copy Editor: Margaret E. Sherman

News Editor: Henning Nielsen

Production Manager: Marianne Snedeker

Assistant—Departments: Sallyann Burgess

Assistant—Administration: Marilyn McKeegan

Eastern Advertising Manager: Thomas G. Orme, 29 W. 39th St., New York

Mid-Western Advertising Manager: Bob Wilson, Millard Ave., Fox River Grove, Ill.

Southeastern Advertising Representatives: Fred W. Smith & Associates, 1201 Forest View Lane, Vesthaven, Birmingham, Ala.

Western Advertising Representatives: Dillenbeck-Galavan Inc., 266 S. Alexandria Ave., Los Angeles 4, Calif.

Advertising Service: Grace Pugsley

SOCIETY OF MINING ENGINEERS OF AIME

President; J. W. Woomer

President-Elect: A. B. Cummins

Past-President: S. D. Michaelson

Regional Vice Presidents: J. D. Forrester, C. E. Lawall, D. W. Scott

Treasurer: R. B. Ladoo

Secretary: John Cameron Fox

Assistant Secretary: Donald R. Tone

Editorial Board: Brower Dellinger (Chairman), N. L. Weiss, Sherwin F. Kelly, R. B. Ladoo, J. C. Fox, R. A. Beals, and member, Advertising Staff.

General Editorial Committee: Brower Dellinger (Chairman), J. W. Chandler, S. E. Erickson, G. L. Judy, Q. D. Singewald, R. A. Beals

Advertising Committee: Sherwin F. Kelly (Chairman), R. A. Beals, T. G. Orme, W. L. Wearly, S. P. Wimpfen, G. V. Woody.

Transactions Editorial Committee: N. L. Weiss (Chairman), B. S. Crocker, J. G. Hall, C. T. Holland, D. R. Irving, R. A. Beals

The AIME also publishes:
Journal of Metals—monthly
Journal of Petroleum Technology—monthly
Transactions of The Metallurgical Society—bimonthly

MOHOLE SIGNALS ATTENTION TO MINING

It is not original to say that the International Geophysical Year became, in effect, International Space year, but to those of us who thought that "geophysical" had something to do with the earth, the emphasis on space competition with Russia was disappointing. That we were not unique in this reaction was revealed by comments and letters that reached us and the reactions to the all-Institute lecture at the February Annual Meeting on "Mining Under the Sea." Now, at last something as bold, and at least a fraction as expensive, as the space tests is being done to further our basic knowledge of the earth.

The project is to bore a hole deep enough to penetrate the Mohorovicic Discontinuity and explore the mantle of the earth. It has been considered infeasible to drill from surface points where the discontinuity is under 20 to 30 miles of crust, but beneath the ocean the total depth of sediment and crust is (at some points), less than the 15,000 to 25,000-ft drilling range already used in petroleum exploration. Drilling a 25,000-ft hole from a point, say, 14,000 ft under water is quite another problem, however.

The first area being considered as a drilling site is north of Puerto Rico adjoining the Puerto Rico Trench. By this summer the search for a favorable site and preliminary studies of engineering techniques should be completed. This test, using seismic techniques and bottom samples will answer the questions: What is the condition of the crust surface (rough, smooth, uniform, etc.)? What fossils might be found in the sediment and crust layers?

Other studies will attempt to develop suitable drilling equipment, combining knowledge from deep drilling for petroleum, offshore drilling, and military experience with large barges and the erection of the Texas Towers at sea.

Beyond a point, progress in exploration methods depends upon greater knowledge of ore-forming processes—beyond a point, extension of this depends on greater knowledge of the crust and, below that, of the mantle at *depth*. This is a step in the right direction.

The project—Mohole—is under the AMSOC-Mohole Committee of the National Academy of Science, the chairman, Gordon Lill of ONR (Office of Naval Research). The initials AMSOC refer to the American Miscellaneous Society (yes, that's right), a group of scientists who set out to outdo the government in choice of acronyms.

In fact, the only thing we can find to criticize about the idea is the name, Mohole. Having gone through the Project-Wham and Operation-Tuesday periods in naming things, we now in the space age seem to be in the "cute names" stage. This sounds like a publicist's dream child, and I, for one, would like to see a return to dignified—if lengthy—project titles like "First Imperial Antarctic Exploration Party" or "First Deep Drillhole Under the Ocean Project."—*Rixford A. Beals*

PROJECT PAYDIRT* *pays off again*

NEW 225 HP CAT NO. 619 TWO-WHEEL TRACTOR

- **First two-wheel tractor to deliver four-wheel speed and roadability!**
- **Matched with new No. 442 Series B LOWBOWL Scraper for new high production with 14 cu. yd. struck capacity!**

This new No. 619 Series B represents a major breakthrough in two-wheel tractor-scraper design. It is the first and only broad application two-wheel machine that combines two-wheel traction with four-wheel speed and roadability. It also affords new unit construction and timesaving accessibility never before built into this type of rig.

The No. 619's new turbocharged engine delivers 225 HP and a torque rise of 20% — for fast acceleration. With a top speed of 30.2 MPH, the No. 619 can really run — and run under conditions that slow down other make two-wheel rigs.

That's because of its roadability. Advanced Caterpillar design has achieved a tractor-scraper balance resulting in rides that "smooth out" to an amazing degree. This balance permits higher speeds for more cycles per day and less operator fatigue.

With all this, new hydraulic steering makes the No. 619 extremely easy to maneuver, yet retains that important "feel of the road" touch. Design permits full 90° turns with a turning diameter of 30 feet.

As for unit construction and accessibility, here's one example: A new swing-away dash allows ready access to the starting engine, air compressor and hydraulic pump. Another example: By removing six capscrews in the planet carrier cover, each axle can be removed from the tractor. The planetaries are interchangeable between sides.

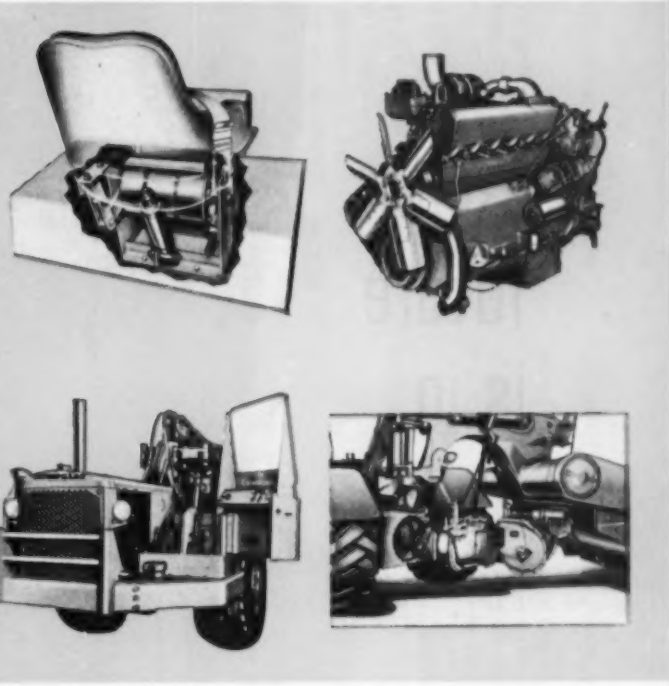
Like all achievements of Caterpillar's Project Paydirt, the No. 619-No. 442 unit has been thoroughly tested. Four years of on-the-job operation prove this: This new "all-job" machine will set new performance records on a broad range of applications.

How much does this mean to you profit-wise? Of course, that depends on your jobs. But this is certain — there's nothing like the new No. 619-No. 442 in the field today. Get the complete facts about it from your Caterpillar Dealer, who backs you with round-the-clock service and parts you can trust. Ask for a demonstration. See for yourself how it can step up production and profits on a wide range of applications.

Caterpillar Tractor Co., Peoria, Illinois, U.S.A.

NEW TORSIONFLEX SEAT. New seat provides "highway" ride on off-highway conditions. Helps conserve operator's energy, lessens his fatigue, enables him to do more work per shift. One of many Caterpillar developments.

NEW TURBOCHARGED CAT ENGINE. Designed to meet the specific requirements of the No. 619. Develops 225 HP and a full 20% torque rise—for fast acceleration from cut. Fuel system permits use of economy-type fuels.



NEW NO. 442 SERIES B LOWBOWL SCRAPER. Matched to the No. 619 for high production. Capacities: 14 cu. yd. struck and 18 cu. yd. heaped. Exclusive Caterpillar LOWBOWL design provides a faster loading rate with less resistance throughout the loading cycle. Also available for use with the No. 619 is the 25-ton-capacity Athey PR619 Rear Dump Trailer.

NEW SWING-AWAY DASH. Permits timesaving access to the starting engine, air compressor and hydraulic pump. Entire left side of engine can be exposed without having to disassemble any major components connected with dash.

NEW UNIT CONSTRUCTION. Offers unmatched accessibility for servicing. Transmission differential and cable control can be quickly removed as unit. Each axle can be pulled out by removing six capscrews from planet carrier cover.

Additional facts about the No. 619-No. 442—Six-speed forward, two-speed reverse constant mesh transmission • Standard wide-base 26.5-25, 24-ply tires all around—optional tread and ply ratings available • Choice of in-seat gasoline starting or direct electric starting • New dry-type air cleaner • Fuel tank capacity—85 U. S. gallons • Shipping width—10 feet, 10 inches.

CATERPILLAR'S *PROJECT PAYDIRT*

* ***PROJECT PAYDIRT:***

Caterpillar's multimillion-dollar research and development program—to meet the continuing challenge of the greatest construction era in history with the most productive earthmoving machines ever developed.

CATERPILLAR

Caterpillar and Cat are Registered Trademarks of Caterpillar Tractor Co.

BORN OF RESEARCH
PROVED IN THE FIELD

Your future is in **your** hands

For every qualified mining man membership in the Society of Mining Engineers of AIME is a basic step toward the development of his career and the attainment of full professional standing.

Every Society members knows of a friend who wants to, or should, join. A little more encouragement—or merely some help in getting his application under way—may be all he needs. Whatever the reason, it is *your* responsibility to him, your profession, and yourself to assist him in becoming a member.

An effective way to acquaint him with the Society is by bringing the candidate to your Local Section meetings. Introductions to other members will demonstrate the important contacts he can make.

Be sure to explain the various activities of SME . . . emphasize the value of *professional prestige* that goes with membership . . . and outline the many benefits such as technical publication, employment assistance, library service, preprints.

You will be helping him and yourself through the expanded services that only a *growing* Society can provide.

Application blanks and other information can be obtained from your Local Section membership chairman; or write the Society of Mining Engineers of AIME, Office of the Secretary, 29 W. 39th St., New York 18, N. Y.

3 New International® Earthmovers

new CAPACITIES (24 yd. scrapers, 27 yd. wagon)

new POWER (375 hp)

new SPEEDS (to 29.1 mph)

Higher speeds possible with optional equipment.

International 24 cu. yd. 295 Payscraper

Heaped: 31 cu. yd.
Overall length: 44'8".

New high visibility color. Optionally available on all three models in either Federal yellow or International Harvester red.

NEW positive push-type ejection assures quick clean dumping of all materials.

NEW advanced lift frame construction with A-frame-type gooseneck that: 1) increases visibility; 2) distributes weight evenly along cross tube; and 3) protects sheaves of bowl lift system.

NEW full 90° turns with power steering.

NEW 375 hp DT-817 turbocharged 6-cylinder diesel engine. See page 4.

NEW cycle-shortening haul speeds to 26.2 mph plus unmatched maneuverability.

NEW exclusive tapered bowl. See next pages.

NEW high 98" apron opening. See pages 2-3.

NEW automotive comfort and control features . . . 16-adjustment bucket seat . . . reach-easy controls . . . unobstructed vision . . . air brakes . . . flush deck.

NEW Model 280 cable control unit . . . finger-tip control . . . fast acting . . . high capacity . . . simple adjustments . . . less maintenance.

See 3-axle models on inside pages...

27 CU. YD. International 495 Paywagon®

Heaped: 40.5 cu. yd.
Payload: 40.5 tons.
Overall length: 50'4½".

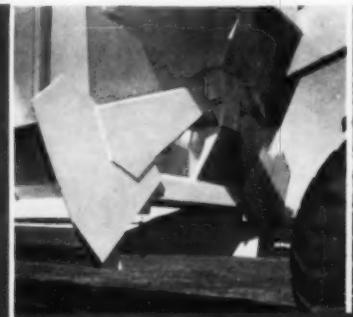
Here in the *27 cu. yd.* International 495 Paywagon is everything that's new and productively *different* in bottom dump design. New 375 hp engine for greater power *per struck yard than any comparable rig.* New higher side and rear end clearance to roll away from any dumped load. New power-opened clamshell doors for positive controlled dumping. New wiper plates put 100% of each load on the fill. New automotive comfort and control features *that* let the operator produce more with less effort. New full 90° turning in either direction. New low design for haul road stability.

New exclusive power-opened clamshell doors afford positive controlled dumping. Operator spot dumps entire load or windrows material in lifts from a few inches on up. Wiper plates shave all material from doors as they raise. Doors gravity close, eliminating complicated mechanism.

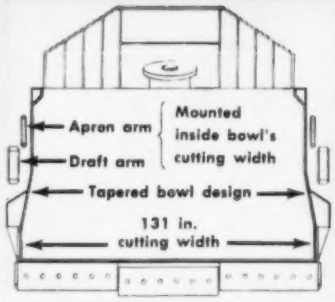
Unmatched 60" rear end dumping clearance lets rig pull fast from fill with no dangling doors dragging on dumped material. Open rear frame lets loader spillage fall through — prevents buildup of "free loading" material.

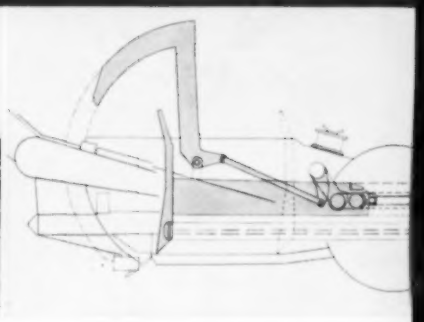
375 HP 495 prime mover gives both 495 Paywagon and 495 Payscraper more hp per struck yard with less gross weight per hp than any similar sized earth mover. Speeds to 29.1 mph. 10'8¼" wheel base. Full 180° non-stop turns can be made within 39'11¾".

NEW high speeds big capacities



fast dumping
unmatched control





This new International 495 Payscraper boils a heaped load into a 24 cu. yd. bowl in less time than any other three-axle scraper in its class and hauls it at speeds up to 29.1 mph. The trailing unit, common to the 295 Payscraper, offers this unmatched combination of features that cut dirt costs: big 131-in. cutting width . . . tapered bowl permits efficient ejection of all materials with equal ease . . . positive forced ejection . . . improved lift frame construction . . . full 90° turns . . . more hp per struck yard than all competitive units . . . wheels and bowl leveling adjustment . . . advanced sheave bearing design . . . and custom designed cable control unit.

Exclusive tapered bowl design: 1) permits scraper and pusher to work inside cut for best traction, less wear on tires, and tracks; 2) causes dirt to boil toward center, reducing side spillage; 3) extra wide bowl bottom provides wider spread, speeds dirt breakaway and lets scraper work cuts against banks.

Positive forced ejection dumps all materials — even wet or frozen clay and gumbo — cleanly and quickly. Six large ball bearing mounted rollers center and guide ejector gate, have 240-hour lube intervals.

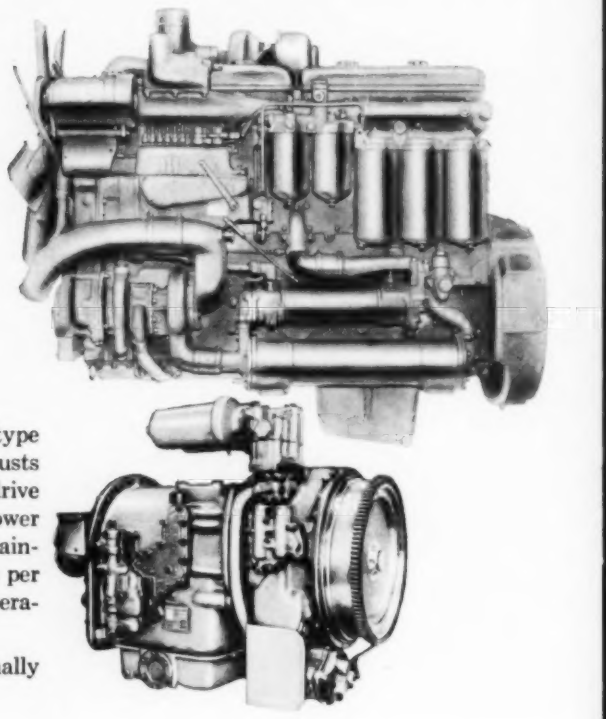
Gaping 98" apron opening plus no bowl cross member permits sure ejection of all materials. Apron opened by exclusive, rear-controlled mechanical linkage. Apron is synchronized with ejector for positive controlled spreading.

24 CU. YD. International 495 Payscraper

Heaped: 31 cu. yd.
Overall length: 50'6¼".

New Turbocharged International DT-817 powers all three giant earthmovers

- Develops 375 hp @ 2100 rpm
- Direct push-button, 24-volt starting
- Positive valve rotators — increase valve life
- Aluminum alloy pistons for fast heat dissipation
- Wet sleeve construction provides additional cooling
- Fully counterbalanced crankshaft for smooth engine performance
- Dual intake and exhaust valves for peak engine efficiency
- Twin plunger injection pump precision meters fuel
- Hang down type replaceable filters for maximum fuel and oil filtering efficiency
- Tri-metal crankshaft bearings for long trouble-free service



Both prime movers are available with 4-speed, planetary type torque converter power shift transmission. It automatically adjusts output torque and speed to fit load requirements. Torqmatic drive makes more power available over the entire range; applies power smoothly and continuously, resulting in less wheel slippage; maintains high tractive effort; and cuts the number of gear shifts per cycle, letting operator concentrate on loading and spreading operations.

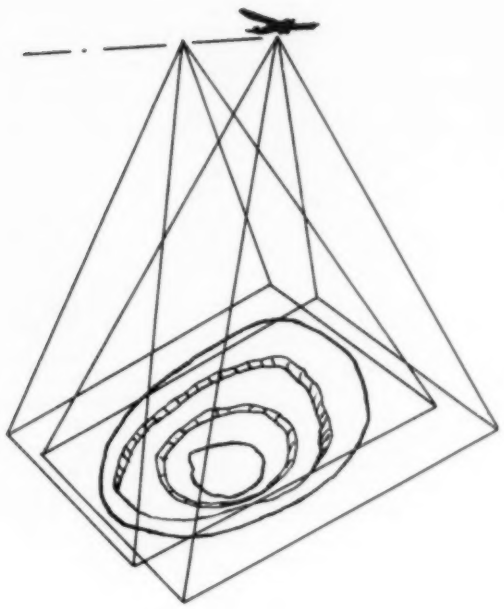
A constant mesh 9-speed manual shift transmission is optionally available on both prime movers.

See your International Construction Equipment Distributor for complete information on these NEW International Earthmovers

International® *Construction Equipment*

International Harvester Co. • 180 N. Michigan Ave., • Chicago 1, Ill.

A COMPLETE POWER PACKAGE: Crawler and Wheeler Tractors . . . Self-Propelled Scrapers and Bottom Dump Wagons . . . Crawler and Rubber-Tired Loaders . . . Off-Highway Haulers . . . Diesel and Carbureted Engines . . . Motor Trucks . . . Farm Tractors and Equipment.



PHOTOGRAMMETRIC METHODS AND THE OPEN PIT MINE

by A. TREMARI and PAUL I. EIMON

Photogrammetrists are studying with new interest the problems of mine mapping and mining engineers are beginning to see what photogrammetry can do for them. Administrators in a number of European and U. S. mines have tried photogrammetric methods and are finding that better maps and data, needed for mine development, can be produced with savings of time, men, and money.

A. TREMARI is a consulting photogrammetrist now with Cartographia de Guatemala. P. I. EIMON is now with American Smelting and Refining Co., Knoxville, Tenn.

In addition to wide use in small scale mapping projects, photogrammetric methods are now used for producing large scale plans and maps in German coal and lignite mines, in some U. S. open pit mines, to inventory TVA coal stock piles, and to compute highway excavation volumes. In each case surveying and map compilation has been made more efficient and accurate by photogrammetry and at significant savings over ground methods.

The physical characteristics of the large open pit mine—and the engineering data needed for its

operation—make it particularly suitable for surveying by photogrammetric methods. Such a mine is constantly changing dimensions within the pit limits. These dimensions, and the resultant volume changes, must be measured periodically for records and planning.

Closely coordinated with the engineering program of an open pit mine, photogrammetric methods make it posible to produce:

1) Periodic maps of the pit at the required scale and accuracies.

2) Cross sections through the pit at regular intervals, necessary for volume computation. Such information can be translated to punch cards and the earth removal volumes computed electronically.

3) Photographic prints for geological interpretation, operation plans, and equipment distribution.

4) An accurate photographic record of mine conditions at a specific date. There would be no delay in mine operations—as experienced in ground surveying—while obtaining this information. The photographic record would be available for checking at any future date.

5) Improved surveying efficiency. Surveying time, surveying control, and engineering costs would be reduced. Engineering surveying personnel could be diverted to other work.

These advantages are tangible and, over a ten year period, the dollar savings are great. Percentagewise, for the mine with a longer life, photogrammetric methods are progressively more economical.

Although versatile, photogrammetric equipment is costly and trained photogrammetrists are required to use it. The mine may purchase a plane, camera, and restitution instruments to do its own photogrammetric survey. Or it may contract the survey, or some phase of it such as the taking of aerial photographs, to a firm specializing in this work. A careful study of comparative costs, which will vary depending on the specific mine (its size, life, personnel, economic potential) will determine which is suitable.

Aerial vs Terrestrial: There are two types of photographs which can be used: aerial and terrestrial. Either one may be suitable for a particular mine. The type of photography to be used will depend on:

- Configuration of the mine—its size and shape —and physical characteristics of the ore
- Present and future development of the mine
- Cost of making aerial photographs
- Possibilities for the establishment of vantage points for terrestrial photographs
- Type and cost of the instrument to be used to compile the map. (Which kind of photographs are used will govern instrument selection in part, although some instruments can use both aerial and terrestrial photographs.)
- Photographic coverage necessary, scale accuracy and ground control requirements
- Weather and flying conditions at the mine.

Obviously the entire ground survey program will not be supplanted by photogrammetry. There will always be grades to be given, lines to be laid out, and other operational surveying to be done.

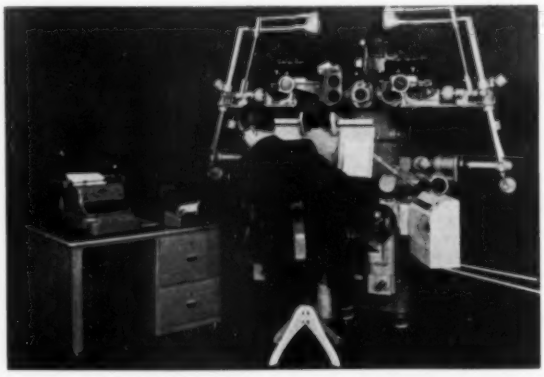
The only ground control necessary in photogrammetric mapping is the permanent primary net around the pit and some secondary points. These secondary points would generally be those established for mine operations.

Terrestrial photographs may be feasible in mines of limited size not requiring extensive photographic coverage. The pit outlines must have good vantage points where the camera stations can be located. These camera stations are selected to cover the area with a minimum number of picture pairs. If dead spots (areas photographically inaccessible) occur, due to the internal surface of the pit, supplementary ground survey would be required. Without good exposure stations terrestrial photography becomes so complicated that it may prove uneconomical.

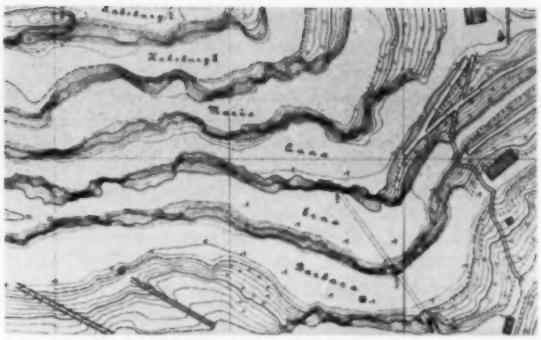
In all cases, the configuration of the pit and its size determine the amount of photography necessary. Aerial photography can cover the entire pit with fewer photographs because these give a vertical view. The vertical view from aerial photographs also gives consistent accuracies throughout. The variation of accuracy, due to the oblique view given by terrestrial photographs, is relative to objective distance from the camera. Aerial photographs of the general mine area can also be taken during the flight, when aerial photography is used.

Weather conditions influence the photographic procedure. For monthly surveys by aerial photography, "generally clear" weather is advisable. For quarterly, semi-annual, or annual surveys, weather conditions are not as crucial and aerial photography would be satisfactory regardless of weather patterns. However, in areas of extended limited visibility and extensive snow fall, terrestrial photography has advantages. Terrestrial photographs can keep up with mining advances, as the work progresses. Longer exposure times are possible, so such photographs can be taken at any time ground survey is possible.

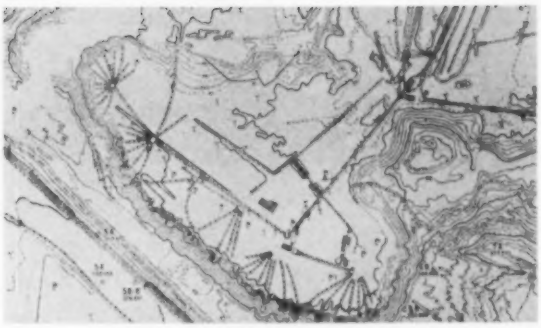
A combination of aerial and terrestrial photography is suitable in some cases. Terrestrial photographs would be used to map, for example, on a monthly basis. Aerial photographs could be flown for quarterly, semi-annual, or annual survey. In this case, restitution instruments to produce maps and sections from both kinds of photographs would be used. And the mine might find it most economical to own terrestrial cameras and to contract for the flight photographs. The organizational structure of the mining and surveying program, as well as other related factors, determines the system to be used.



Zeiss C-8 Stereoplanigraph with Ecomat.



Portion of plan of Bosnien iron mine showing detailed contours and benches. Plotting by Zeiss Stereoplanigraph. Contour interval 1 meter.



Plan view of Wackersdorf mine, derived photogrammetrically. Original scale 1:2000, contour interval 1 meter.

Photogrammetric methods make possible more precise mapping than provided by existing ground surveying methods used in most mines. Open pit mapping scales vary between mines and companies. For administration and planning purposes, these are 1 in.=200 ft to 1 in.=500 ft. For engineering control and development within the pit, scales of 1 in.=50 ft and 1 in.=100 ft are used.

Cross sections can be derived photogrammetrically using the same photographic model as that used in drawing the plan map. From the directly-plotted profiles (cross sections) or the readings of various heights along the profiles, volume data can be accurately derived by planimeter. The precision of profiles, derived numerically from the photographs in a good instrument, is much higher than that derived from contour lines.

The current U. S. highway program is using profile readings derived photogrammetrically. These profile readings are recorded on punched cards for an electronic computer.[7] As the states using this method are processing large amounts of raw data, the volume figures are thus obtained quickly, economically, and accurately.

Every operating mine must have periodic maps. The mining company and its engineering staff want these produced as accurately and cheaply as possible with minimum interruption to the mining operation.

Photogrammetric methods can fulfill these requirements in most cases. The mining engineer, however, wants to know specifically how such methods fit into his survey program. All pits generally differ in shape, size, location, and survey requirements. It is therefore not possible to give a universal prescription of how photogrammetry is to be applied in open pit mines. The following examples show how photogrammetry has been used in open pit mining and similar operations.

EXAMPLES OF USE

Lignite—Brown Coal Mines in Germany: Both terrestrial and aerial methods of photogrammetry have been used in German coal mines as far back as 1920. In the period from 1938-1951, terrestrial methods were used extensively but the aerial methods have progressively gained importance. Currently, aerial photography has virtually supplanted the terrestrial.[4]

In 1954, experimental mapping of a brown coal mine in western Germany was carried out, using terrestrial cameras. Checks on 20 points showed the mapping accuracy to be 6½ in. for horizontal measurements and 1 in. for vertical measurements. Because the mine was essentially a stripping operation, the changing nature and form of the terrain made it difficult to establish good exposure stations. For this reason, the terrestrial method was not used.[10]

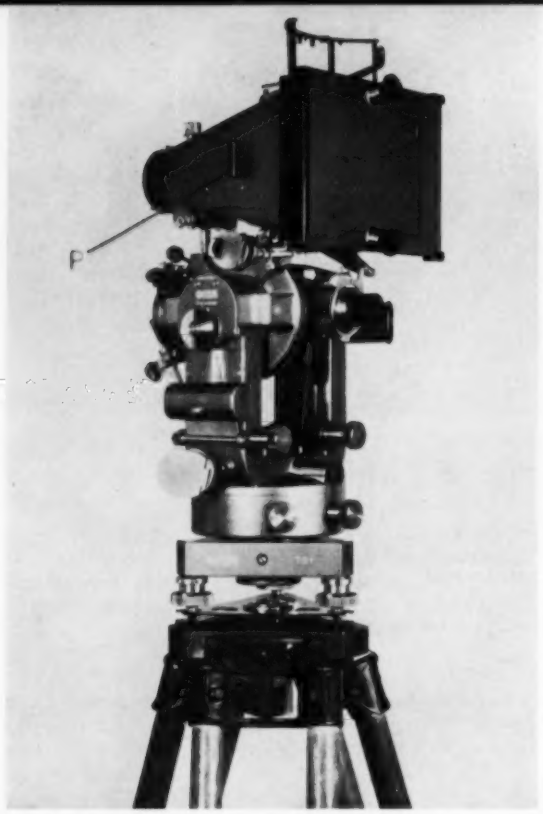
Presently, photogrammetric methods with electronic computation are used for periodic surveying in the Rhine open cast lignite mines. These mines, located near Roddergrube, West Germany, have a daily output of 85,000 metric tons. Production involves the removal of 262,000 cu yd of overburden daily.

Known survey points are controlled and marked with 5x5-in. signals. These points are selected so as to be always reusable. The photography is flown at an altitude of 1,000 meters (3000 ft). Plotting is

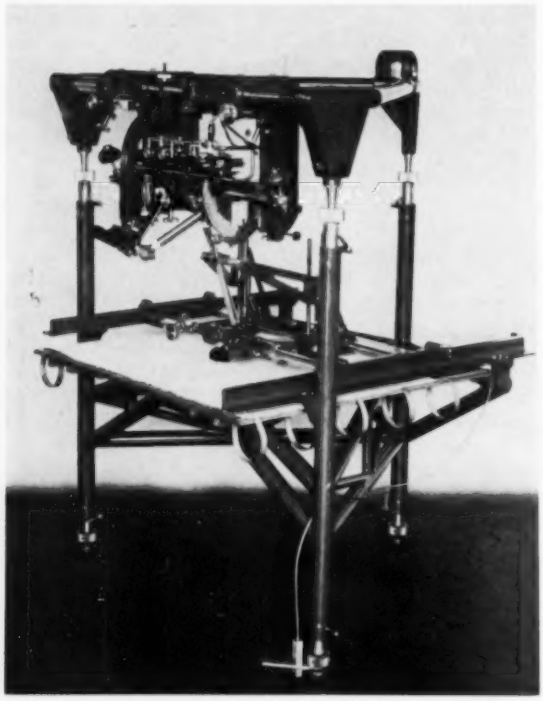
Photogrammetric Mapping in European Coal Mines

No.	Mining District	Country	Contractor	Year	Map Scales	Surface Area, Kilometers
1	Rheinisch-Westfalische	Germany	Hansa-Luftbild	1920 to 1945	1/5000 to 1/10000	8,000
2	Saar	Germany	Hansa-Luftbild	—	1/8000	600
3	Gross-Mohlau North Wolfen/Sa.	Germany	—	—	1/2000	—
4	Sudetenland	Germany (now Czechoslavakia)	Hansa-Luftbild	before 1945	1/1000	6
5	Ruhr	Germany	Hansa-Luftbild	—	—	—
6	Rheinelbe Mine	Germany	Hansa-Luftbild	—	—	—
7	Marbach bei Bochum	Germany	Bochumer Verein	1945	1/6000	—
8	Droger Revier	Hungary	Salgo-Tarjaner	before 1925	1/10000	—
9	Zonguldak	Turkey	MTA Institute	1939 to 1940	1/10000	1,000

From: "Bisheri Anwendung der Photogrammetrie im Bergbau," by F. Manek, Table 5, page 9, *Vermessungs Informationen.*



Galileo Phototheodolite FTG-1 consists of precision camera mounted on theodolite. Photo pairs for use in plotting machine are made with instrument like this, taking all measurements and recording directions.



Galileo-Santoni Stereosimplex, Model II, is a second-order plotting instrument adaptable for either aerial or terrestrial photographs. Photographs from the Galileo FTG-1 can be used directly in this instrument.

done by Zeiss Stereoplanigraph, a high precision, first order instrument. Personnel required to operate these instruments are part of the regular mine staff.

Maps are produced on scales between 1:500 and 1:2000 (1 in.=42 ft to 1 in.=167 ft). Accuracies obtained in this case are 4 in. for both horizontal and vertical measurements.

Numerical profile data is obtained directly from the Stereoplanigraph and registered on punched cards. Volume computations are done by Remington Rand computers from the punched cards.[5]

Tennessee Valley Authority Stockpiles: The Authority (headquarters in Knoxville, Tenn.) utilizes photogrammetry to inventory large coal piles. TVA has its own restitution instruments (Kelsh Plotter of 7½ times magnification).

Stockpiles are flown periodically at an altitude of 1200 ft. The piles are contoured with 1-ft intervals on the slopes and ½-ft auxiliary on the top. The mapping scale is 1 in.=40 ft.

To determine comparative accuracy possible with various surveying methods, TVA used three different methods on a static pile in a three-year period and tabulated results.

Year	Method	Results (Tons)	Difference, Pct, Plane Table	Difference, Pct, Cross Sections
1950	Cross Section	26,148	2.9	—
1951	Plane Table	25,405	—	2.7
1952	Aerial Survey	26,098	2.7	0.2

This indicates that the difference in volume-determination between the plane table and photogrammetric method was about 3 pct. The difference between cross section and the photogrammetric method was 0.2 pct.

The aerial survey shows much closer agreement with the more accurate cross section surveying than the plane table methods. TVA found that photogrammetric methods were 25 pct less expensive than ground surveying.[5]

Bingham Canyon Copper Mine: Kennecott Copper Corp. is using photogrammetric methods for periodic surveying of a 972-acre open pit mine at Bingham Canyon, Utah.

Working under supervision of the mine's engineers, an aerial photogrammetric firm takes the aerial photographs, runs a ground survey to establish horizontal and vertical control points identifiable on the photos, and prepares the required map. The firm uses a Kelsh plotter for stereophotogrammetric map making.[6]

Kennecott realizes specific advantages in this method over traditional ground survey methods:

- Maps are up to date. These are produced in about four weeks. The same job, with ground survey, once took five-to-six months.
- Cost savings are in proportion to the time saved.
- Field investigations are held to a minimum—an aid in compiling confidential information.
- Areas inaccessible, dangerous, or difficult for a ground crew to survey can be quickly photographed and mapped.
- Weather and seasonal problems do not hold up planning work, once the photographs are taken.
- The mine can get a definite cutoff date, so contour changes, waste and ore removed can be accurately determined during a given period.

• Engineering personnel can be better utilized since it is not tied up for long periods on mapping and computation.

The ready availability of accurate maps and data makes it possible for the engineering staff at Bingham Canyon to plan ahead, realistically. Ore and waste areas can be spotted in for each level, their location predetermined by drill holes. The core drillings identify areas of lower and higher grade ores which can be worked and blended for efficiency during processing. The right ratio of overburden stripping to ore recovery can be better maintained.

SUMMARY

Photogrammetric methods, integrated with and adapted to the engineering problems of a particular open pit mine, can provide more accurate maps, in shorter time and at lower cost than the more usual ground survey methods.

The photogrammetric method will not supplant the ground survey program entirely. It will, however, release the engineering staff for more significant work.

The photographs, used in the photogrammetric method, are valuable for more than mapping. They provide a basis for accurate measurements, can be analysed for topographical and geological details, significant to the mine, and are a permanent record, available for easy reference at any time.

Application of photogrammetric methods, as described, can achieve desired results. The open pit mine is peculiarly suitable for photogrammetric surveying. But, careful study of conditions, costs, and the kind and degree of information the mining engineers and administrators want, should be made at a specific mine before photogrammetric methods are adopted.

Where the conditions, suggested in this paper, are met, initial experiments indicate that photogrammetric methods have positive and desirable values. Photogrammetric methods can fill the engineering needs at the large open pit mine with a new degree of efficiency accuracy, and economy.

ACKNOWLEDGMENTS

Dipl. Ing. F. E. Ackerman, International Training Center for Aerial Survey, Delft, Holland, for critically reviewing the paper. Dipl. Ing. H. Heyll, chief mining engineer, Roddergrubbe, West Germany, for information on the Heyll experiment. Tom Edwards, Chief Engineer, Lake Asbestos of Quebec, Ltd., and Art Barber, Geologist, Anaconda Co., Tuscon, Ariz., for general information about surveying and mapping procedures in the U. S. and Canada.

BIBLIOGRAPHY

[1] H. D. Grosse, "Anwendung der Luftbildmessung in Braunkolenbergbau," *Vermessungtechnik*, Heft 12/1954.

[2] H. Harry, "The Present Situation of Cadastral Surveys by the Photogrammetric Method", Report presented at the Sept. 16, 1954 session of Comm IV, International Society of Photogrammetry, Rome.

[3] H. Heyll, "Einsatzmoglichkeiten elektronischer Rechentechniken für markscheiderische Berechnungen, dargestellt am Beispiel einer Braunkohlentagebau-Aufnahme", *Braunkohle, Warme und Energie*, 1957, pp. 341-356.

[4] F. Manek, "Bisherige Anwendung der Photogrammetrie im Bergbau", *Vermessungtechnik*, Heft, 3/1954.

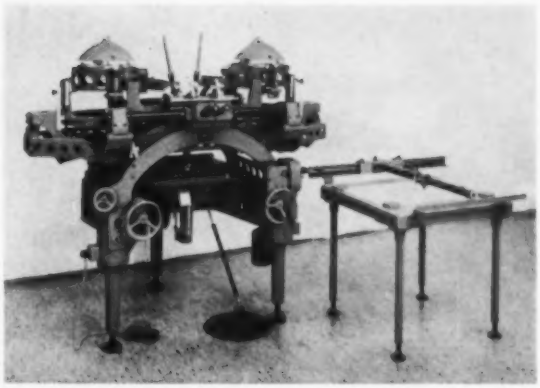
[5] W. S. Massa, "Inventory of Large Coal Piles", *Photogrammetric Engineering*, Vol. XXIV, No. 1, March 1958.

[6] "Aerial Photogrammetry—Application of a new science to open pit mining", *Mining Review*, July 1956.

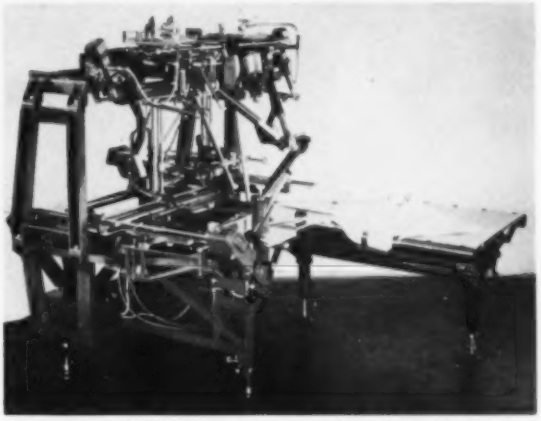
[7] C. L. Miller, "Digital Terrain Model Approach to Highway Earthwork Analysis", Massachusetts Institute of Technology, Publication 112, August 1957.

[8] K. Schwidefsky, "New Aids for Numerical Photogrammetry", *Photogrammetria*, Vol. XIV, No. 1, 1957/1958.

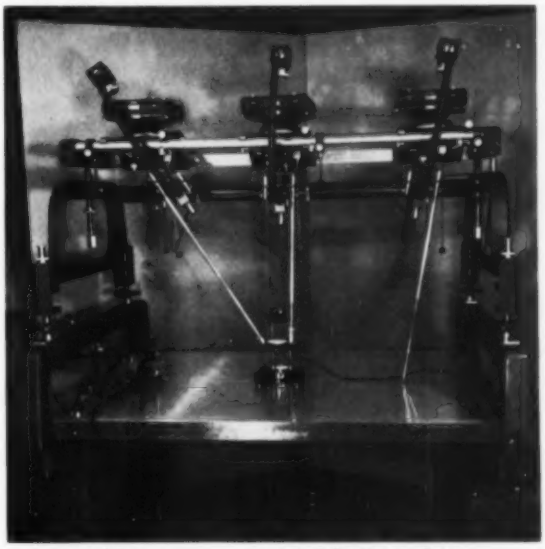
[10] J. Toppler, (Technishe Hochschule, Dresden), "Massenermittlung im Braunkolentagebau Mittels Terresticher Stereophotogrammetrie", *Vermessungtechnik*, Heft, 5/1957.



The Wild A-8 stereoplotting machine is a first-order instrument.



Galileo-Santoni Stereosimplex, Model III, provides first order accuracy from vertical, tilted, and "tipped" photographs up to 9x9-in. size.



Kelsh Instrument Co. Model KPP-3 plotter.

A restitution instrument is an optical-mechanical photogrammetric instrument which orients the negative or diapositives in nearly the same conditions as existed during the exposure of each picture pair. Metrical data can be obtained and plotted from the optical model thus created.

SOUTH AFRICAN MINING—A TIME TO INVEST?

by HOWARD S. STROUTH

Investors and mining companies in the U. S. have recently shown increased interest in the Union of South Africa. This has been sparked partially by the founding in the U. S. of a large investment trust which will hold substantial shares in many of the leading gold and uranium producers.

The average U. S. mining man's judgment of the Union, however, may be somewhat clouded by recent headline news. We are inclined to take a strong dislike to the stern measures of the present Union government with regard to its native majority. Others possibly think of South Africa in terms of a British colony which, under pressure of rising African nationalism, must eventually be abandoned. These concepts frequently suffer for lack of precise information.

Politics: The Union of South Africa was carved from a hostile environment by brave men and, by right of conquest, it is their country. The fact that there is a majority of natives and a minority of whites seems merely to prove that the latter have dealt somewhat more humanely with the native populace than did the conquerors of the Western Hemisphere.

The major political and human injustices in our eyes, and in those of many people of the Union, are the ones that deprived people of modern education and mixed ancestry of their rights. The present government's basic thinking in abrogating these rights is simple. It feels that since it is engaged in a struggle in which the long-range odds seem to be in favor of the African native populace, the white minority which also claims the country can survive only by the use of force. The government is convinced that natives and whites cannot live side by side in peace, unless the white minority is in full control. It also believes that in nationalistic and extremist movements it is the educated men of mixed ancestry who are the natural leaders and the only ones capable of translating discontent into organized hostility.

The opinions of Field Marshal Smuts, Cecil Rhodes, and Lord Malvern are more in keeping with present world opinion. This group believes a place should be cleared in Western society for every civilized (i.e., educated) man, with the hope that instead of revolting he would share the Western viewpoint and strive for coexistence.

It is difficult, however, to assess the reaction of a propertied minority in the country of its birth which finds its rights, privileges, and sometimes its very existence threatened.

In the city of Johannesburgh there is a native policeman in every store entrance at night. To walk in the shadow of the railroad station without protection means taking your life in your hands. The corridors of every floor of the plush Carlton Hotel are patrolled by more policemen. Almost everyone driving a motor vehicle is armed and pledged to question strange natives in his neighborhood after curfew. The loss of a weapon brings severe penalties.

Still, one can buy an opposition paper on any street corner and members of the present government have been hounded for years by female mem-

H. S. STROUTH is Director, Palmiet Chrome Mines Ltd., Palmiet Fontein, Transvaal, Union of South Africa.

What are the opportunities for the U. S. investor in the Union of South Africa? Can he reclaim his mining capital with fair profit, or are local troubles so great that they make investing purely a gamble? What about minerals? Have most of the great reserves already been claimed? Are labor and transportation adequate? Are present mine owners operating satisfactorily? Here is firsthand information, on a very personal basis, on politics, economic atmosphere, and mining opportunities in the Union.

bers of the opposition wearing the black sashes representing their mourning for the loss of civil liberties.

Labor Conditions: Impressions related here were gathered in sections of Transvaal and Cape Province and considerable differences in type of labor and treatment could well exist in other parts.

At the Palmiet mine, as in other mines along the Merensky Reef, the local people, called Basutu, will not work underground and the workers are imported, through an agency system, from the Rhodesias, Nyassaland, and Central Africa. Most of them are Zulu tribesmen of the M'Schonga and Matabili tribes. They are good workers with amazing stamina who work, without obvious discomfort, seams that sometimes narrow to a clearance of only 40 in. Due to lack of space the drillers often operate their stopers with their feet while lying on their backs.

There are stringent government requirements regarding mine company food, medical care and sanitary facilities; a government inspection system insures that workers are fed and well housed.

In substance, the law calls for the housing of native workers in barracks type compound buildings, but this might not apply to all mines and certainly the smaller mines have much leeway. A large number of men sleep in each cubicle on bench-like arrangements and a small built-in stove is situated in the center of the white-washed room. The compound is wire enclosed and normally the natives are not permitted to leave. Employment is limited to two to three years at most and the workers are then returned to their homes. The men may not bring women or family to the work site. Their food is cooked army-style by mines management and sanitary facilities and medical care are excellent.

Circumvention of the law by smaller mines, or those located in more remote regions, is frequent. Eventually the government will probably have to adjust certain of these laws which were mainly designed to keep the imported natives from settling down in so-called white regions with their families.

Where there is more leeway, natives bring families and some small cattle. With the help and materials furnished by the mining company they build a native village somewhat similar to the one of their origin. Order is kept by one or two native policemen. Food rations are issued and prepared by family units. Wherever possible, temporary acreage is allotted for growing extra vegetables. Needless to say, companies try to hold good workers as long as possible.

Experience would indicate that this latter procedure, one thoroughly in keeping with the paternalistic attitude of the Boer farmers of the region, not only makes for a better and more contented labor force, but also avoids the many problems resulting from virtually locking up a number of young men.

Labor cost is still very cheap by U. S. standards. Performance, as with most cheap labor, is low, but specialists (drillers, etc.) do an amazingly good job.

Transportation & Harbor Facilities: Transportation in South Africa is doubtlessly the largest single drawback to expansion and new industry. Everywhere, ore which cannot be moved is stockpiled along railroad tracks, in station dumps, and at the

Boshock station is served by only a single railroad track and the loading of ore is a job for men with shovels.

mine. Rail lines to the Lohathla or Rustenburg regions, which furnish substantial quantities of chromite, iron, and manganese, are all single track. They are government-owned and attempts by users to help finance a second track have so far been unsuccessful. The problem is also aggravated by lack of rolling stock and trained personnel. Natives are excluded from most of these jobs and the temporary influx of European workers has slowed down to a trickle.

Most of the chromite producers are allocated rail car space for only a few thousand tons each month, and the same applies to certain of the iron and manganese producers. The situation becomes even more critical during harvest season since food and fuel have priority. Because most of these minerals have a relatively low per-ton value and narrow profit margin, operations held down to this low tonnage tend to become uneconomical every time the market price of these commodities drops 10 to 15 pct. Fuel for trucks is both expensive and hard to obtain. Hired trucks are not very dependable and the cargo weight is often overestimated because of improper weighing facilities. This not only makes production control difficult but also easily adds 10 to 20 pct to normal trucking cost.

At Palmiet and other chromite operations, additional losses are incurred since it takes the cargo several weeks, in open cars, to reach its destination at Lourenco Marques, some 385 miles distant. Wind and rain cause losses at mine dumps, station dumps, and shipping dumps at harbor. Harbor facilities are very crowded and there are constant worries about meeting commitments to consumers. Because of railroad restrictions it takes a period of time to accumulate a shipment at harbor and, at the same time, dumping is only permitted for a short period.

There is little doubt, however, that these difficulties will be partially or totally resolved over a period of time.

Production Possibilities: Because of existing difficulties, the country offers enormous opportunities for enterprising mining companies.

The Union of South Africa was, and remains, predominantly an agricultural country with little venture capital to spare. Capital for industrial expansion has been furnished in the past largely by British interests. But these have suffered certain setbacks due to limitation of funds in England, the political climate in South Africa, and the United Kingdom's high tax rate on income derived from such ventures.

For this reason it is possible today to purchase the shares of operating mines in the Union, with large proven reserves yielding a profit up to 12 pct, selling in some cases at not higher than three to four years' projected earnings, with no value assigned to properties or reserves. By the same token it is possible to purchase operating mines outright at roughly the same cost ratio or lower.

Ferrous Ores: Opportunities in this field are virtually unlimited. Take for instance the Postmasburg region near Lohathla where the Germans did considerable geological work in the 1930's. In a top secret report they estimated the potential manganese and high grade iron wealth of the region in the billions of tons. It was their intention that after having won the war in Europe during their initial offensive, they would try to seize this huge reservoir for their steel production. There are a substantial number of operators in this region but there is much room for more, even before transportation improves.

Other large deposits are located more conveniently but many require treatment because of their high titanium content. Here again a few wisely invested dollars might pay large dividends. Steel, wire, and ferro-alloy industries are growing steadily in the Union and will gradually find expanding markets in South Africa and for export.

Chrome: There are a substantial number of chromite mines along the Merensky Reef, which even after these many years is only partially explored. Many known properties can probably be acquired for less than $100,000, with reserves up to the million-ton figure or higher. Mining is usually done to a 500 to 1000-ft depth and grade averages 42 to 45 pct CrO_2. The iron:chromite ratio is lower than 3:1 but usually better than 2:1. With modern processing most of this material can be used for metallurgical purposes. It sells for about 60 pct of the Turkish metallurgical grade.

The seven seams specifically identified are relatively narrow—the widest about 38 in.—but with local methods and rather simple installations, ore can easily be mined and concentrated to 48 to 50 pct Cr at a cost of some 100 shillings (about $14), f.o.b. Lourenco Marques. The market price varies, with the needs of the steel industry, from 120 to 200 shillings per ton. A few thousand tons of concentrates per month represent a very modest dollar volume but the idea of acquiring a small operation with a large future potential at low cost should have appeal. Assuming that it would be possible to purchase such a property for $250,000, including equipment, production of 30,000 tons of concentrate per year would bring a profit of at least 30 shillings per ton or £45,000 ($126,000) before taxes. This, in effect, would mean return of the investment in 24 months. If there were a million tons of proven ore on the property, a recoverable 500,000 tons of concentrates would mean a £750,000 profit potential, before taxes. It would be difficult to buy that much value elsewhere for £250,000.

Uranium & Gold: There is at present a group of

some eight major producers with an excellent yield whose shares are low priced according to share-to-earnings ratio. It might be difficult to compete with long-established mines, and new uranium contracts are now precluded, but new gold finds are still being made.

Coal & Energy: There are many coal mines in the Union which are well located and exceedingly cheap to operate. Average production cost per ton, including loading, does not exceed 10 shillings. Many of these deposits, particularly those owned by British interests and completely written off, can be bought cheaply because of double taxation on present British owners. Prospects for export and other markets appear excellent.

Eventually, it might be possible to tap some of the water resources from long distances such as is being done by the Rhodesias, whose major power source is in the Belgian Congo. If cheaper and improved energy-producing reactors can be fed with South African uranium the value of most mining properties will multiply overnight.

Pegmatites: The Union is honeycombed by pegmatites: cassiderite, columbite, tantalite, beryl, lithium, and many other minerals of commercial value. (The author has had a natural aversion toward pegmatites for many years and finds it difficult to envisage any large scale operations resulting from any of these deposits.) Most of them are presently being worked on a very small tonnage basis, with traders providing outlets and picking up the material at regular intervals.

Copper: In the past the Union has yielded up to 100 million lb of copper a year, and substantial deposits no doubt will still be found. Extensions of the formations carrying the large Rhodesian copper orebodies can be observed in the Union, especially near the Rhodesian border. Work in this region might prove most profitable.

An orebody discovered and proven by the Patino interests in this region was acquired within the last few years by a large South African company. The company obtained a proven orebody of more than 10 million tons of good grade, suitable for strip mining, merely for repayment of expenses incurred by the Patino group and a small carried interest. The South African producer made an excellent investment as its subsequent balance sheets proved. The Patino group was definitely strong enough to finance this operation out of pockets, but company policy, and possibly tax considerations, made it as advisable for them to sell, as it was opportune for the purchaser to buy.

Tailings are recovered by hand in this operation.

Jamieson tables are used for heavy media separation at the Palmiet Chrome Mines Ltd. operation in Transvaal.

Other Minerals: Space does not permit covering the many other minerals found and successfully processed and shipped in the Union. Notable among these are asbestos, vermiculite, platinum, and some of the rare earth compounds and steel-hardening agents.

Conclusion: Consider these criteria for taking up mining property in the Union:

Is there enough evidence of reserves, grade, and successful operations to measure the risk?

Are local difficulties so great that they counterbalance the value of the deposits and their potential?

Can a long range program be envisaged that will compensate all the effort, money, and daring necessary to build new mines?

The mining record of the Union for the last 50 years speaks for itself. Local difficulties exist, but these are among the many calculated risks peculiar to mining. And the risks are not out of proportion. In addition to unusual opportunities, U. S. investors could doubtlessly obtain considerable tax relief, binding guaranties regarding conversion of funds, export of dividends in U. S. dollars, and insurance against possible seizure, nationalization, or acts of war.

There are definite possibilities, in some instances, of repaying investments within two to three years, and it seems unlikely that any drastic political changes will occur in the Union of South Africa within the next ten years.

It must be remembered that South Africa is still a new frontier. The newspapers are reminiscent of San Francisco in the last century with illegal stock promotions, disbarred lawyers, bank frauds, and marauding natives featured on the front pages. Moreover, the cracks in the wall from regular earthquakes will save anyone from excessive complacency.

But stripped of trivia this is a great challenge with tremendous opportunities which have not diminished over the years. For anyone looking for good odds, South Africa might well be the place.

RAILROAD CAR-DUMPER COAL SAMPLING

If coal samples are to retain mine identity, they can only be taken during car dumping. Here is an effective method of obtaining really representative samples.

by W. R. REICHENSTEIN and ARMAND BUR

Since coal is one of the largest cost items in the production of electricity, its analysis for heat value and composition has been the subject of intensive study. Sampling started with crude hand methods, out of the railroad car or barge or from moving conveyor discharge, and progressed to reliable mechanical in-plant sampling systems.

The mechanical system takes its sample from a falling stream of coal such as a conveyor discharge or crusher discharge hopper. But this has a disadvantage in that the identity of the coal is lost. Coal is shipped to the user in train-loads, often made up of shipments from various mines. When the cars are dumped into hoppers and the coal conveyed to the power station, the various shipments become mixed because residual coal remains in hoppers and chutes.

Because of bonus-penalty contracts, both vendors and buyers are extremely interested in obtaining a representative sample of the coal as received. The only sure way to obtain such a sample is to take it from the stream of coal as the railroad car is being dumped.

Study at Cleveland Electric Illuminating Co. revealed that through the cycle of car dumping, coal starts to flow after the car has been rotated about 90° from its initial position, and emptying is completed after a total rotation of 150°. Since representation is the principle of all sampling, the next step was to link a sampling process with the angle of coal flow. Three lengths of 8-in. pipe were attached to the car dumper sidewall, spaced to obtain proper representation across a standard railroad car. The sampler is shown in accompanying diagrams.

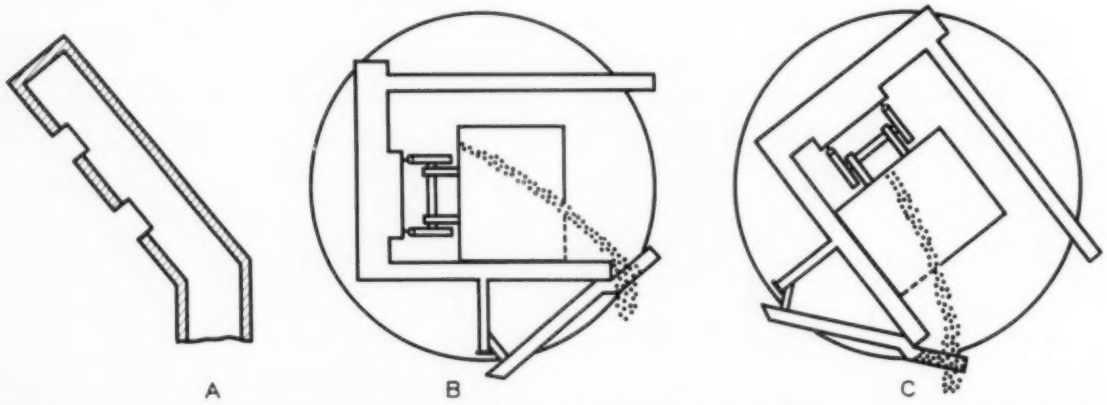
Each of these three pipes was fixed at a given angle to cut through the falling stream of coal at right angles. Two ports were cut in each of the three tubes, the opening sufficient to pass 5-in. lumps. Spacing of the ports coincides with a desired sample procurement relative to car depth.

As the dumper returns to the upright position, the sample tubes pass through a vertical position and the sample of coal gravitates to the collecting hopper, attached to the tubes. When the dumper has reached its upright position the hopper gate opens, automatically discharging the coal sample to the belt feeder. The belt feeder conveys the coal to the primary crusher, where it is reduced to—¼-in. size. A secondary reciprocating type of cutter traverses the crushed coal being discharged, depositing the sample directly into a mason jar.

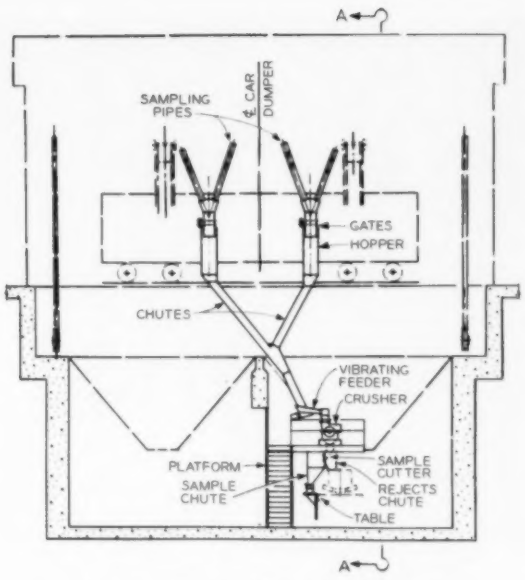
Improved System: Further improvements to the sampling system were made by Fairfield Engineering Co., manufacturers of this type of equipment (patented), at the Frank M. Tait station of Dayton Power and Light Co.

The Tait installation employs four-tube primary sample collection. Here space required the primary crusher to be located below track level. Samples from each pair of sampling tubes are collected and converge into a common hopper. Each hopper is fitted with an automatic gate which opens when the car dumper has reached its final upright position.

W. R. REICHENSTEIN is Vice President, Fairfield Engineering Co., Marion, Ohio. A. BUR is Engineer, Mechanical Engineering Dept., Cleveland Electric Illuminating Co., Cleveland.

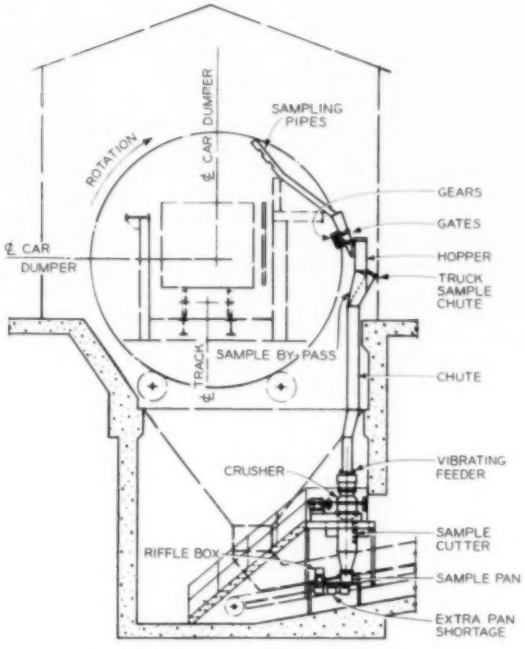


Sampler system developed at Cleveland Electric Illuminating Co. A: Cross section of sampling tube. B: Coal entering first ports of sampling tube from upper half of car. C: Coal entering second ports from lower half of car.

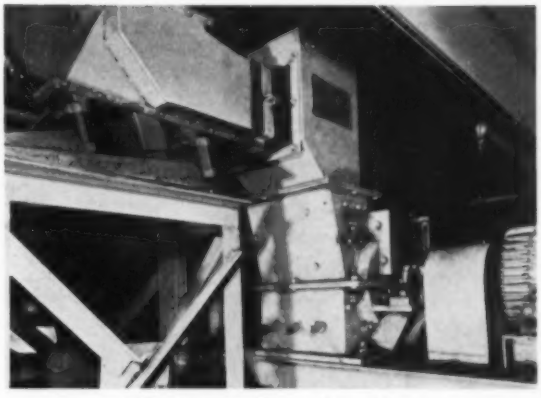


Tait station sampler, side elevation.

Sampling tubes at dumper.



Tait station sampler, end elevation.



Vibrating feeder and crusher.

The two discharges comprising the gross sample converge to a single chute which delivers the sample to a vibrating feeder. The feeder controls rate of flow to the primary crusher.

The primary crusher, a ring hammer mill, reduces the sample to $-\frac{1}{4}$-in. The secondary sample is obtained by a reciprocating type of cutter installed below the crusher discharge. Rejects are automatically returned to one of the main 400-tph belt feeders. Individual car samples are collected in 2-qt mason jars. Multiple-car composite samples are collected in a pan and the pan contents passed through a riffle box. Rejects are discharged to the belt feeder.

The entire system, with the exception of the sampling tubes, is constructed of $\frac{1}{4}$-in. stainless steel. Incorporated into the system are auxiliary chutes located at grade level. These may be used for truck sampling or for processing special coal samples from boiler tests. The four 8-in. diam sample tubes with two 5-in. ports each produce a gross sample weighing 160 lb per car. The secondary sampler with a cutter width of 1 in. and a speed of 7.5 in. per sec, with a travel of 16 in., produces 0.19 lb per cut. With an interval of 7 sec, there would be 17 cuts equaling 3.3 lb or enough to fill one 2-qt mason jar. Two minutes are allowed for collection of primary sample, crushing, and secondary sampling.

Leading utilities have checked the car dumper method of sampling and found its accuracy meets the standards set by ASTM code.

Accuracy Check: The car-dumper sampler was

Automatic gates and collecting chutes.

Sample collection table.

Table I. Car-Dumper vs Hand Sampling, Single-Car Lots

	First Car	
	Ash, Pct	Moisture, Pct
Car-dumper sample	9.9	3.9
Hand-belt sample	9.2	3.8
Difference	0.7	0.1
	Second Car	
	Ash, Pct	Moisture, Pct
Car-dumper sample	9.4	5.4
Hand-belt sample	9.4	5.1
Difference	0.0	0.3

Table II. Car-Dumper vs Hand Sampling, Five Car-Lot

	Btu as Received	Ash, Pct	Moisture, Pct
Car-dumper sample	12,990	10.9	3.1
Hand-belt sample	12,990	10.5	3.1
Difference	0	0.4	0.0

Table III. Car-Dumper vs Mechanical-Belt Sampling, 16 and 30-Car Lots

	16-Car Lot		
	Btu as Received	Ash, Pct	Moisture, Pct
Car-dumper sample	13,025	10.5	3.5
Mechanical-belt sample	12,980	10.4	3.8
Difference	45	0.1	0.3
	30-Car Lot		
	Btu as Received	Ash, Pct	Moisture, Pct
Car-dumper sample	12,750	9.6	5.5
Mechanical-belt sample	12,760	9.6	5.4
Difference	10	0.0	0.1

checked for accuracy, using two single-car lots of coal, a five-car lot, a 16-car lot, and a 30-car lot.

Table I shows the ash and moisture analysis of the single-car lot checks comparing the car-dumper sampler against hand-belt sampling. The size of coal sampled was mine run. Total weight of the car dumper sample was 108 lb, taken in six increments; total weight of the hand sample was 48 lb, also taken in six increments.

Table II shows the ash, moisture, and Btu analysis of the five-car lot check, again comparing the car-dumper sampler against hand-belt sampling of run of mine coal. Total weight of the car-dumper sample was 540 lb, taken in 30 increments; total weight of the hand-belt sample was 180 lb, also taken in 30 increments.

Table III shows the ash, moisture, and Btu analysis of the 16 and 30-car lot checks comparing the car-dumper sampler against the mechanical-belt sampler.

The size of coal sampled during the 16-car lot check was 73 pct mine run and 27 pct slack, by volume. Total weight of the car-dumper sample was 1728 lb, taken in 96 increments, and that of the mechanical-belt sample was 1280 lb, taken in 64 increments.

The size of coal sampled during the 30-car lot check was 90 pct mine run and 10 pct slack, by volume. Total weight of the car-dumper sample was 3240 lb, taken in 180 increments, and that of the mechanical-belt sample was 2400 lb, taken in 120 increments.

If space requirements permit, secondary crushing and further sample reductions or splitting can be incorporated into new designs.

In addition to the stations mentioned, car dumper sampling systems have been, or are being installed at Sunbury station, Pennsylvania Power & Light Co.; Milliken station, New York State Electric & Gas Corp.; Arthur Kill station, Consolidated Edison Co. of New York.

DESIGNING ORE-TREATMENT PILOT PLANTS

by ROBERT D. MACDONALD and FRANK M. STEPHENS JR.

As processes for handling low-grade or complex ores become more complicated and as new methods are found, the need arises for more complete and detailed pilot-plant studies to protect the capital investment required for a full-scale plant.

Occasionally a process is firm technically, but there is a need for a demonstration plant that will convince nontechnical men of the wisdom of investing in a full-scale operation.

A pilot plant is a working model which can be used to demonstrate that the process involved is technically and economically sound, to check that the various pieces of equipment are workable, and to gather data on process variables that affect the design of a larger plant. Pilot operation is planned for a period long enough for the limits of all process variables to be established and the effect of recirculating streams proved.

Expenditures always must be justified by a reasonable expectation of future savings. As a practical matter, pilot-plant operation involves compromises on size and type of equipment, location of the plant, duration of operation, and, particularly, cost. All too often, detailed cost calculations are postponed until the pilot plant is in operation, and then it suddenly becomes clear that the plant is costing more than had been anticipated. The operation may be shut down before optimum operating conditions have been established.

Another difficulty is that the men who control the pilot plant's funds and operations, although men of vision with the courage to pioneer, have limited patience. If not technically trained, they may have a hard time understanding the delays and difficulties that frequently accompany pilot operations.

R. D. MACDONALD and F. M. STEPHENS JR., are, respectively, Assistant Chief, Minerals Beneficiation Div., and Chief, Extractive Metallurgy Div., with Battelle Memorial Institute, Columbus, Ohio.

Too often the men with the enthusiasm, know-how, and ability to improvise to make a pilot plant work are considered too valuable to waste on this work. In the over-all operation of a company, this may seem to be so, but, in the long run, it is good economy to provide an important pilot plant with topnotch management.

Aside from their availability, securing good men is sometimes difficult because pilot operations are not always pleasant jobs. The equipment frequently breaks down in the middle of the night. Constant revisions and changes in plans cause frustrating delays, and the limitations of time and money keep constant pressure on the operating crew.

Design Considerations: In designing the pilot plant, we must consider carefully the following:

1) Representative plant feed
2) Location
3) Size
4) Availability of equipment
5) Alternative flow schemes
6) Space for auxiliaries
7) Material balance
8) Heat balance
9) Layout—plan and elevation
10) Equipment flowsheet
11) Piping
12) Control and instrumentation
13) Estimated capital and operating costs
14) Reagents
15) Operating manpower
16) Maintenance facilities
17) Safety
18) Drawings
19) Collection of adequate data
20) Coordination
21) Provisions for adequate chemical analyses
22) Interpretation and reporting of the data
23) Translation of results to commercial scale

The detail involved is sometimes used as a reason for skipping the pilot plant entirely, for pushing the philosophy, "Let's just lick our troubles once, on a big scale," "Let's train the operating crew to overcome the difficulties, rather than a nucleus pilot plant only," or, "The time we save by skipping the pilot plant will more than repay the cost of licking the problems on a plant scale." The attitude is rarely profitable.

If we assume that the process in question has been shown to justify a pilot operation on the laboratory scale, and if preliminary study indicates an optimistic possible return of at least 5 to 10 pct for a fairly standard process, 10 to 20 pct for a process containing some new unit process steps, and 25 to 35 pct for a completely revolutionary process, and if a market survey shows the plant product will have a good sale, then each of the 23 items must be studied carefully. Unfortunately, we must study them all simultaneously and integrate them in order to get results.

Representative Plant Feed: One of the advantages of a small plant is that it is possible to mix thoroughly a quantity of ore large enough to last a full pilot campaign. We can do this, for instance, by repeated passes through a sampling plant, by bedding, or by repeated coning.

Sometimes it is unreasonable to expect a representative feed. The mine may not be fully developed, or may be hardly open, the orebody may be naturally variable, or the eventual plant feed may come from many widely separated orebodies. In this situation, the process being piloted must be inherently capable of absorbing large variations in the grade of feed, or piloting is useless.

Location: The following checklist shows some of the important items that must be considered in locating a pilot plant:

1) Is the site accessible, or will new roads or rail spurs be required?
2) Are all necessary utilities present or easily obtained?
3) Is the area large enough?
4) Is there adequate manpower in the vicinity?
5) Can the necessary ore supply be maintained?
6) Can pilot-plant waste products be disposed of?
7) Are good communication systems available?
8) Is the location safe?
9) Can supplies be obtained easily?
10) Will climate permit consistent operation?

In addition, any special requirements of the process itself should receive consideration. For example, if a sulfide ore is being processed and oxidation during transit or storage will affect its behavior in the plant, then it may be necessary to locate the proposed pilot plant near the mine.

Care should be taken to insure that the conditions expected to prevail at the commercial plant are duplicated for the pilot plant, even if considerable extra expense is involved.

Size: An often-used rule of thumb states that a pilot plant should have a capacity not greater than 50 times that of bench-scale plant and the final full scale plant a capacity no greater than 50 times that of the pilot plant. This is a generalization only, which cannot always be realized because of time and money available. However, operating troubles invariably accompany too large a jump in the scale of operation.

Satisfactory ore-treatment pilot operation can be carried on at 100 to 200 lb per hr of ore or even less. Operation of these small plants is often hampered, however, by the many compromises made to *size*. Where pulps must be handled, flow rates are so small that lines and pumps plug continually and the circuit is constantly surging; the thickeners do not bed properly; it is very difficult to feed small quantities of reagents steadily, especially solid ones; the quantity of wash water required is so large in proportion to the volume of the circuit that dilution becomes a problem; and, in general, so much time is spent making the wheels go around that there is little or no time for the primary purpose of collecting *significant* data.

A further disadvantage of the small pilot plant is the limited quantity of final product. For further metallurgical studies, for detailed chemical analyses, for the working out of complicated purification methods, or for market surveys and the establishment of product usefulness, many hundreds of pounds and sometimes many tons of product are required. In general, ore-dressing pilot plants that treat no less than 10 tpd of ore or, if at all possible, 25 tpd have a better chance of providing useful data than smaller plants.

Many metallurgists prefer to pilot only those unit operations that involve innovations in standard practice and to rely on calculated integration to a large extent. This is wise development procedure, provided that none of the possible variables is neglected.

Alternative Flow Schemes: When a process for pilot testing is first considered it is seldom so fixed that a single flow path can be prescribed logically. Possible alternative flows must be anticipated, including space for building extension and making such auxiliaries as power, steam, and water supply large enough to stand any reasonable future load. This predicting is difficult and can be done only with reliable laboratory results.

Material Balance: Before any equipment or piping can be sized, the quantities of solid, liquid, and gas entering and leaving each piece must be estimated and the whole flow plan integrated and balanced. It usually is sufficient to assume approximate splits in material from a given unit step, but flow of material in circulating streams must balance exactly, to avoid undesirable build-ups.

Several material balances may be desirable, assuming several different sets of conditions, and the pilot plant must be big enough to accommodate equipment for any probable flow plans.

A common error is to ignore waste disposal. Possible toxicity of plant waste must be considered also.

Heat Balance: If heat is significant, a rough heat balance must be made to estimate quantities of steam and fuel required, to specify insulation and heat exchangers, to know effects of evaporation on the sizes of various flows, and to specify condensers and disengaging apparatus.

Detailed heat balances are seldom worthwhile for ore-treatment pilot plants, because surface-to-volume ratios differ so greatly in the small plant from those in the proposed full-scale plant that heat-balance data can only be approximated.

Operating temperatures, radiation loss, evaporation, the extent of flashing, and the amount of cooling water or air needed can normally be calculated with as much accuracy as the experimental data justify.

Equipment Flowsheet: Sometimes the material-

balance flowsheet and the equipment flowsheet are combined, but this usually results in a very complex and confusing drawing, which requires the use of colored lines and numbers to differentiate flows and specifications.

The equipment flowsheet is often a stumbling block for process planners because it requires recognition of the sometimes very difficult processes of moving solids, liquids, gases, and pulps from one piece of equipment to another. In one instance, a process had only five simple steps, but before it could be piloted 60 separate types of equipment, some in duplicate, had to be specified. Most of these were conveyors, elevators, pumps, hoppers, bins, weighing and measuring devices, surge tanks, mixing tanks, water and gas-recovery devices, and the like, but all were vital to the working of the process.

Layout—Plan and Elevation: Layout is of great importance, not only for obtaining maximum economy of space and proper elevation of equipment for effective sequence of flow, but also for determining location of control points and details of instruments to be specified.

After planning in rough draft, equipment specifications must be checked. For instance, the hydraulic head on transfer pumps can be established only after the layout elevation is set. Belt conveyors are suitable only if the horizontal distance between terminals permits a slope of 20° or less. Small quantities of high-gravity pulp must be fed by gravity down a steep slope. Launders and piping must be sized correctly to provide entrainment velocity at all points, especially if any horizontal runs are required.

Piping: Proper pipe design is highly important for pilot plants in which pulps are to be handled, but unless the material is toxic or volatile, detailed piping diagrams usually are not required. Rubber or plastic piping is frequently ideal; not only is it light and easily worked, but it is also strong and corrosion resistant, and can be run around corners and in limited spaces without extensive fitting.

A common failing is to supply pipe so large that flow velocity is not great enough to keep the pipes clean. Passageways should not be obstructed by pipes at waist height, nor valves placed just beyond the top of the highest ladder, as has been done in more than one plant.

Horizontal runs of pipe and right-angle bends should be avoided in lines carrying pulp.

Control and Instrumentation: Many ore-treatment plants are operated successfully with no instruments at all, or, at most, with a vanning plaque, a pulp-density balance, and a pH meter. Furthermore, in numerous plants in which complicated instrumentation has been tried, it has taken more man-hours to keep the instruments in operating order than to run the rest of the plant. Instruments must provide useful information, and not just numbers to file. However, some processes, such as roasting, distillation, gas-phase reactions, and pressure-vessel operation require fairly elaborate instrumentation. In general, ore-treatment plants are tending more and more to become chemical beneficiation plants, and the number of justifiable instruments is increasing constantly.

Valves are not mere instruments, but primary means of control in most processes, and great care should be taken in their choice and installation. For successful operation of any plant handling pulps, valves must not be used for throttling. They must be either full open or completely closed. Exceptions to this are rubber pinchcocks and annulus valves, but even these should not be used for small flows. Automatic valves should be pneumatically operated, with an electrically-actuated solenoid valve to start and stop control air.

A central control panel is desirable so that the course of the processing can be followed without a continual chase to check on each piece of equipment. Continual checking should not be eliminated but one man should be informed continuously of overall operating conditions.

Estimated Capital and Operating Costs: To justify piloting, a pre-design estimate should be made of operating and capital costs. As the pilot work progresses, this should be revised continually and brought up to date. This is primary information; without it, the secondary technical data become meaningless. Great care can be justified in preparing cost estimates to make them realistic. Our most important consideration is that no possible expense item is neglected.

Reagents: Reagent preparation and handling can become major labor items. A common error in design is to fail to provide adequate facilities and space for storage and preparation. Dry reagents, such as lime or filter aid, must sometimes be used in large quantities. Acids usually must be diluted for use, and soluble reagents, such as soda ash or caustic soda, dissolved and adjusted to proper concentration. An important point is to provide for obtaining the weight of all reagents fed.

Operating Manpower: Some pilot operations are carried on with the bare minimum of manpower, as a demonstration of the simplicity of the process and the low manpower requirements of the final plant. This may be a bad policy in that it puts primary emphasis on operating, rather than on obtaining essential data required to insure further process simplification. In addition to the men required to keep the plant in operation, men are needed to collect data and others to analyze and interpret them. Sometimes all these functions can be carried on by the same men, but usually at the cost of quantity and quality of the data collected.

Furthermore, it is poor economy to expect operators to be mechanics and electricians. These supporting skills should be provided on a full or part-time basis to avoid amateur maintenance and neglect of the primary purpose of collecting *significant* data.

Maintenance Facilities: Many pilot operations are carried on without a maintenance shop, relying on the services of some nearby shop for the necessary aid, but this is never satisfactory. Many repair jobs are needed when the nearby shop is closed, other work has priority, detailed drawings are required, or union regulations interfere.

Minimum shop facilities should include a small lathe, drill press, welding equipment, power grinder, power hack saw, power pipe threader and good supply of hand tools. If the pilot plant has specialized equipment, special tools for maintenance should be available.

An adequate storeroom is of primary importance. The storekeeper may not be needed full time, but he should be available.

Safety: Pilot plants are inherently hazardous, because equipment is being continually altered. Safety provisions are difficult to make and rules are difficult to enforce. The best safeguard is an alert

and well-trained crew. Points of known hazard should be protected by automatic overload devices, check valves, high-temperature or high-level alarms, automatic gas analyzers, and the like.

Probably the most important points are to leave plenty of room around equipment to make maintenance and cleaning easy and to install enough safety showers and eye fountains.

Drawings: An inspired gadgeteer or experienced man usually can devise something that will work well enough for the purpose of the pilot operation, but not necessarily as well as if carefully thought-out drawings had been prepared and followed. This is a matter for compromise. Few pilot operations can tolerate the time lost in preparing detailed drawings down to the last nut and bolt, but most can justify assembly-type drawings, which give over-all dimensions and specify types and makes of equipment, proper elevations, sizes of piping, and locations of valves and control equipment.

Collection of Adequate Data: Unless the data collected are complete enough to define operating conditions without question, the pilot operation is in vain. For this reason, it is well to collect more data than are necessary, rather than to finish with pertinent figures missing. On the other hand, if too many samples are taken they can be a burden to the analysts. They stretch time for reporting key operating analyses, and increase expenses tremendously. However, figures that cost little or nothing to record, such as extra temperature readings, level readings, pressure readings, and logbooks of events of technical interest, are worth far more than the trouble taken to acquire them.

Sampling is a part of pilot operation requiring careful study. Unless samples are representative, and taken at the proper time, they may be not only meaningless, but misleading. For instance, if the composition of a given tank is of interest, samples of the feed, discharge, and the tank contents at several different levels must be taken almost simultaneously. If the feed is sampled one hour, the tank an hour later, and the discharge at the end of the shift, the samples are meaningless; and yet this frequently happens in large and otherwise well-operated plants. It is imperative that the men who take the samples be trained to recognize the importance of a good sample.

Some plants find it worthwhile to have a sampler whose business it is to take all the samples and be sure they are taken right. This avoids such things as waiting to take a sample until conditions look good, or avoiding samples that would make a shift *look bad*. These things happen if sampling is left in the hands of an operator who does not recognize the importance of a true sample taken at the proper time.

Automatic samplers are good investments where they can be used to advantage.

The interval of sampling will vary. For unit operations that fluctuate badly, a sample may be needed every 15 min. Usually a composite sample should be taken covering a whole shift, as well as a sample representing flow at any given time.

Data are confusing and meaningless unless well organized, tabulated, graphed, and interpreted. Toward this end, it is well to provide each unit operation or perhaps each operator with a mimeographed logsheet to be filled out at specified intervals. Considerable thought should be given to design of the logsheets, to provide for maximum accumulation of data without unduly taxing the patience of the operator. It should be the responsibility of the plant metallurgist to collect logsheets every shift, file them, transfer data to cumulative records, and interpret changes they show.

Coordination: Since pilot-plant operation is normally limited in time and frequently behind schedule, especially in starting, it is well to save as much time as possible by giving careful consideration to job coordination during construction. Plant layout affects this coordination considerably. Consideration should be given to location of equipment for accessibility, room for repair, minimum runs of piping, and ease of erection.

Adequate Chemical Analyses: Two kinds of analyses are required in pilot work: control assays and detailed analyses for making metallurgical balances. Plant design must provide space for both functions. An analytical laboratory may be available in some other location. If not, it must be provided for, either within the pilot plant or, preferably, in a separate building close by. Control analyses, such as free-acid determinations, iodide coppers, iron determinations, or fluorimetric analyses of uranium solutions, can be made by the operators several times each shift. A limited amount of space and equipment for this is desirable in the plant itself, preferably in a centrally located room with bench space provided with water, air, gas, electricity, and perhaps a small vacuum pump for quick filtrations. A sink, hot plate, and hood are desirable, as well as space for keeping samples and special parts and tools and a desk for keeping records.

Interpretation and Reporting of Data: Pilot operations sometimes produce results at an alarming rate. Not only must careful provision be made to collect this mountain of numbers in an orderly manner, as mentioned, but one or more men must have the responsibility of continuously collating and correlating, always with the objective of preparing detailed and well documented reports. The reports must both record the data and present an interpretation of it. Graphical presentation is helpful, as are photographs of critical equipment and operations.

In many pilot operations, the temptation is to leave interpretation and reporting of data until the pilot operation is concluded, simply because of lack of manpower. This practice cannot be discouraged too strongly. At least one man should be charged with the responsibility of reporting data in every pilot operation and, if the process is very complex, more than one man may be needed. The work of interpreting data may be required on a three-shift round-the-clock basis to keep pace with the pilot-plant operation and to make results of any change of conditions known as soon as possible.

Translating Results to Commercial Scale: Successful translation of pilot results to commercial scale depends primarily on preparation of good reports. Beyond this, however, it is always desirable to use as many as possible of key pilot-plant personnel in designing the large plant. Inevitably there will be questions that cannot be answered by referring to reports, or that can be answered more quickly or completely by the pilot plant operators.

It is sometimes worthwhile to keep the pilot plant in operation after construction of the large plant, with continual accumulation of more and better data on simplified and more economical operation. This may require continual change of plant design, but is often justified economically.

THE 1959 JACKLING LECTURE

"A successful career in mining geology, consulting work and operation of substantial iron ore properties, and for his lecture, 'Economic History of the Lake Superior Iron District.' "—Citation of the Jackling Award Committee.

ECONOMIC HISTORY OF THE LAKE SUPERIOR IRON DISTRICT

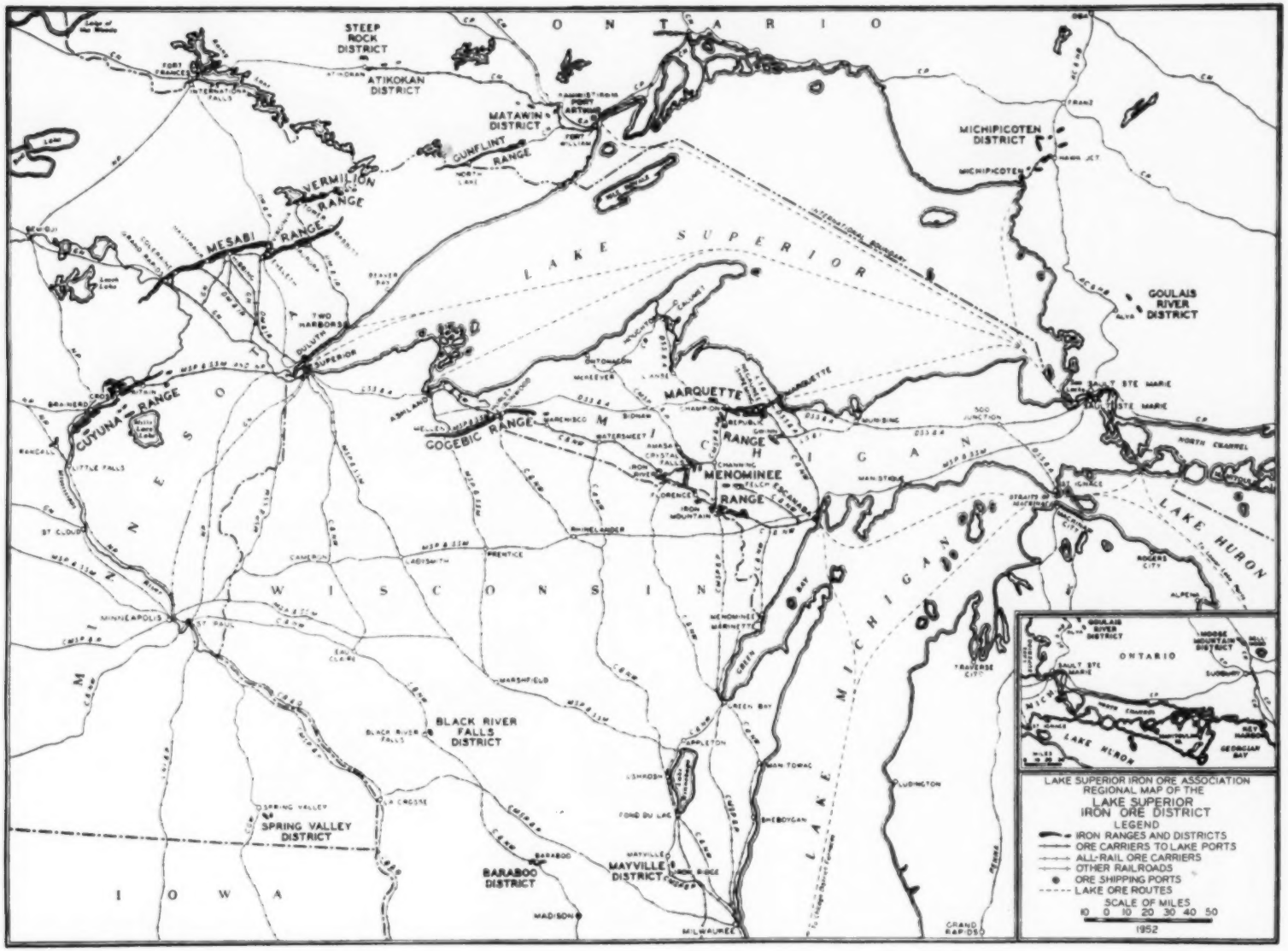
by R. S. ARCHIBALD

The subject of this paper is particularly appropriate, since Daniel C. Jackling was active in early exploitation of taconites on the Mesabi Range and contributed greatly to their later economic development. After his success in developing the low grade porphyries in the West he looked for more worlds to conquer, and so undertook the concentration of low grade taconites, from which he hoped to produce commercial ore. Mesabi Iron Co., organized in 1919, actually did produce merchantable sinter from taconites in 1922. The enterprise did not prove commercial at the time, as cost of production was high and the surplus of iron ore in the Lake Superior District already contributed to a low market price, but this same property has since been developed by Reserve Mining Co. The work done by Jackling had much to do with the success of this later venture.

Iron ore was first discovered on the Marquette Range in Michigan in 1845. The first ore from this range came from the old Jackson mine in Negaunee in 1848. During these early years this property and others on the Marquette produced limited tonnages for transportation to Lower Lakes and for consumption by charcoal furnaces in the area, where a plentiful supply of hardwoods furnished the charcoal for iron smelting. The Marquette and other ranges tributary to Lake Superior did not produce much ore for transportation to Lower Lakes until the locks at Sault Ste. Marie were constructed, but from the time the first lock at the "Soo" was completed in 1855 these ores were transported through the locks to consumer centers in the East. The Marquette Range has a history of continuous production from 1848 to the present day.

In 1877 the Menominee Range was discovered at the location of the old Penn Mines near Vulcan, Mich. There were further discoveries of ore on the old Menominee Range and at Florence, Wis., in 1880 and at Iron River and Crystal Falls, Mich., in 1882. Penn Mines continued in operation from the date of their discovery until they were finally exhausted by Pickands-Mather in 1945, but operations still continue on the Menominee in the Crystal Falls and Iron River districts. Ore is shipped to a lake port at Escanaba, Mich.

R. S. ARCHIBALD is a Mining Geologist, Negaunee, Mich.
TP 59A91. Manuscript, Jan. 14, 1959. San Francisco Meeting, February 1959. AIME Trans., Vol. 214, 1959.


ONTARIO
STEEP ROCK DISTRICT
ATIKOKAN DISTRICT
MATAWIN DISTRICT
GUNFLINT RANGE
VERMILION RANGE
MESABI RANGE
MICHIPICOTEN DISTRICT
GOULAIS RIVER DISTRICT
LAKE SUPERIOR
TWO HARBORS
DULUTH
SUPERIOR
CUYUNA RANGE
GOGEBIC RANGE
MARQUETTE RANGE
MENOMINEE RANGE
MICHIGAN
LAKE HURON
MINNESOTA
WISCONSIN
MINNEAPOLIS
BLACK RIVER FALLS DISTRICT
SPRING VALLEY DISTRICT
BARABOO DISTRICT
MAYVILLE DISTRICT
IOWA
LAKE MICHIGAN
LAKE SUPERIOR IRON ORE ASSOCIATION
REGIONAL MAP OF THE
LAKE SUPERIOR
IRON ORE DISTRICT
LEGEND
IRON RANGES AND DISTRICTS
ORE CARRIERS TO LAKE PORTS
ALL-RAIL ORE CARRIERS
OTHER RAILROADS
ORE SHIPPING PORTS
LAKE ORE ROUTES
SCALE OF MILES
10 0 10 20 30 40 50
1952

The Gogebic Range was discovered in 1884 at the location of the present Colby mine, and the first ore was shipped that same year by Joseph Sellwood. This ore was shipped all-rail to Milwaukee and thence loaded into vessels and transported to Cleveland, Ohio. The Gogebic Range extended from Gogebic County, Michigan, into Iron County, Wisconsin, and iron ore operations are being carried on in both Michigan and Wisconsin at the present time. This ore is shipped to a lake port at Ashland, Wis.

The Vermillion Range was discovered in 1882 at the Soudan mine at Tower, Minn., a property still in operation. Further discoveries were made on the Vermillion Range a little later, and two other mines on this range continue in production. The ore is shipped to a lake port at Two Harbors, Minn.

The Mesabi, discovered at Mountain Iron in 1890 by the Merritt brothers, began shipment in 1892. This range, developed for a length of some 80 miles, contains the largest reserve of iron ore in the U. S. The ore is shipped to lake ports at Duluth and Two Harbors, Minn., and Superior, Wis.

On the Cuyuna Range (1904) near Deerwood, Minn., the first mine was placed in operation in 1911. The range continues in operation to the present. Ore is shipped to a lake port at Superior, Wis.

In addition to these major iron ore ranges in the Lake Superior District, iron ore is being produced in Fillmore County, Minnesota. This is not a Lake Superior ore. It is shipped all-rail to consumer centers in the Middle West.

Iron ore was also found at Baraboo and Mayville, Wis. These ranges are sometimes classified in the Lake Superior District, but the geological occurrence is different from that of the Lake Superior ores. The mines on these ranges have been exhausted. From 1849 to 1928 a total of 3 million tons was shipped by rail to Chicago and other nearby consumer centers.

Michipicoten Range, northwest of Sault Ste. Marie in Canada, began producing ore in 1891 and has operated intermittently since then. The siderite from this range becomes a manganiferous iron ore of good quality when roasted and is classified as a Lake Superior ore. The ore is shipped all-rail to Sault Ste. Marie, Ont., and also to a lake port at Michipicoten Harbor on Lake Superior.

In 1945 production began at Ontario's Steep Rock Range, discovered in 1938. Steep Rock produces a true Lake Superior ore very similar to the ore of the Vermillion Range. It is shipped from the mine to Port Arthur, Ont., on Lake Superior. This property has operated continuously since 1945.

During the interval following discovery of the Mesabi and Cuyuna ranges, active development and exploration of these ranges was continued and by 1915 had progressed to the point where reasonable estimates of developed tonnage on all of the Lake Superior iron ranges were available. Likewise in the interval between 1900 and 1915 mergers of steel companies into large self-contained units were occurring. U. S. Steel Corp. was organized in 1901, and several other large integrated steel companies had either built or projected plants. A large and dependable source of iron ore was a necessity in organizing and financing these steel plants. Oliver Iron Mining Co., established by U. S. Steel as its iron ore subsidiary, proceeded to acquire large reserves on the Michigan and Minnesota ranges through purchases of existing corporations and leases of known ore reserves. Oliver carried on intensive exploration on the Mesabi Range to develop reserves for this corporation. In 1906 it acquired a lease on the extensive reserves owned by Great Northern Iron Ore Co.

Through these activities Oliver acquired large reserves on the Old Ranges—including the Marquette, Menominee, Gogebic, and Vermillion—and a large share of reserves on the Mesabi. Other steel corporations charged that they were being cut off from the sources of iron ore by the Oliver company, and there was talk in Washington of bringing an anti-trust suit to compel Oliver to release the Great Northern Ore properties. These properties were surrendered by the Oliver company in 1941 and were available to the open market and to other steel companies that were short of ore.

By 1915 the Mesabi and Cuyuna ranges had been rather thoroughly explored. The large discoveries on the Gogebic Range at Wakefield had been made, and reasonable estimates of tonnage were available on all the ranges:

Range	Tons
Marquette	82,547,000
Menominee	89,645,000
Gogebic	64,211,000
Mesabi	1,389,000,000
Vermillion	11,013,000
Cuyuna	72,403,000

This 1915 date was immediately before World War I and it will be noted that at that time there was a total tonnage of 1.689 billion developed in the Lake Superior District.

During an interval included by the two great wars the following tonnages were shipped from the Lake Superior District:

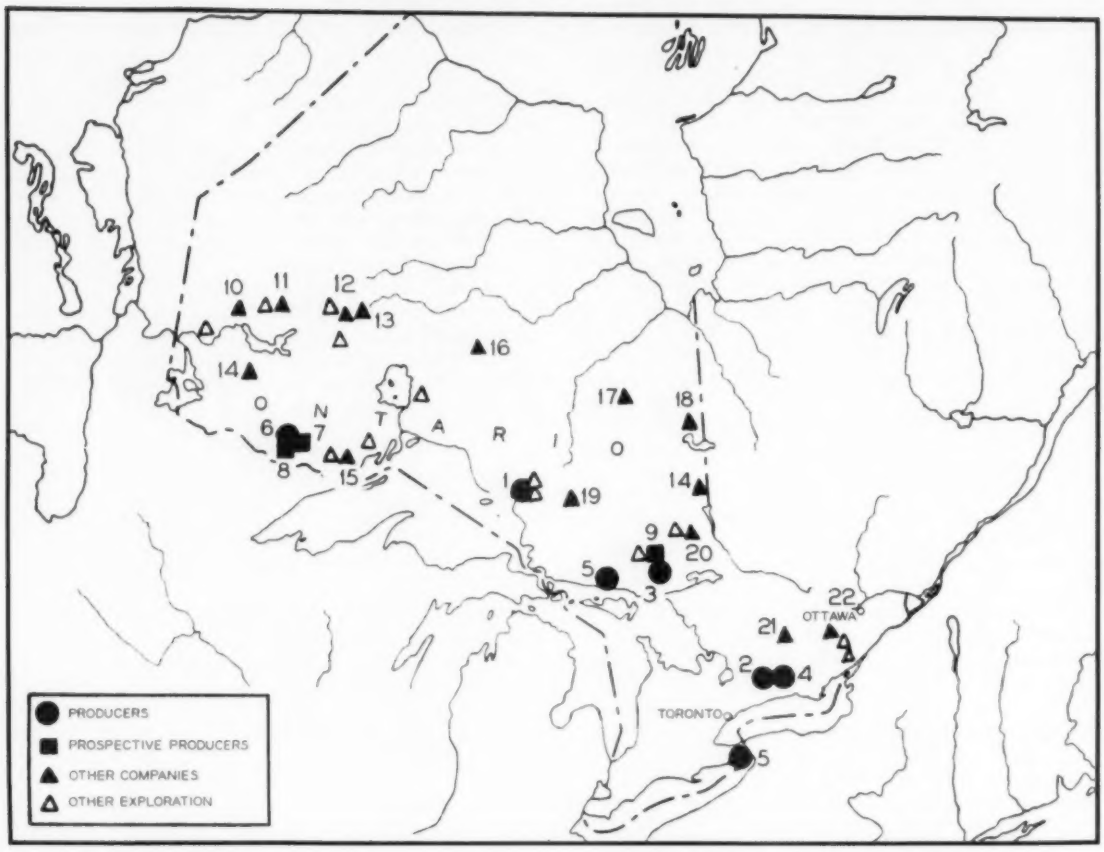
Period		Total, Millions of Tons	Yearly Average, Millions of Tons
Preceding World War I	1910 to 1914	207	41.4
During World War I	1915 to 1919	290	58
Preceding World War II	1920 to 1939	841	42
During World War II	1940 to 1945	485	81

By January 1946, at the end of World War II, developed reserves of iron ore in the Lake Superior District amounted to 1.183 billion tons. From the beginning of World War I to the end of World War II, that is, 1915 to 1945 inclusive, shipments from the Lake Superior District totaled 1.616 billion tons. The gain in reserves during this period in the Lake Superior District was about a billion tons—this in spite of the fact that the District was considered to be developed in 1915.

Factors Underlying Increase in Reserves: This gain in reserves occurred first because the deep mines on the Old Ranges continud to develop reserves in depth and there was little shrinkage in these reserves from year to year. Some new mines were discovered on the Old Ranges, but most of the increase in reserves resulted from extension of known orebodies either laterally or in depth. The great gain in reserves on the Mesabi Range was primarily due to change in mining methods and improvement in ore dressing.

Prior to 1926 all open pit mining was done by the railroad-type shovel loading to railway cars that were hauled out of the pit by steam locomotives. In 1926 the first revolving shovel was tried on the Mesabi by Oliver Iron Mining Co. In 1937 the first truck was used by E. P. Remer at the Leetonia mine in hauling ore from the pit to a loading ramp. Later

IRON ORE IN ONTARIO DURING 1957



Producers of Iron Ore

1. Algoma Ore Properties Ltd.
2. Clarken Development Ltd.
3. International Nickel Co. of Canada Ltd.
4. Marmoraton Mining Co. Ltd.
5. Noranda Mines Ltd.
6. Steep Rock Iron Mines Ltd.

Prospective Producers with Announced Production Plans

7. Caland Ore Co. Ltd.
8. Canadian Charleson Ltd.
9. Lowphos Ore Ltd.

Some Exploration and Development Companies

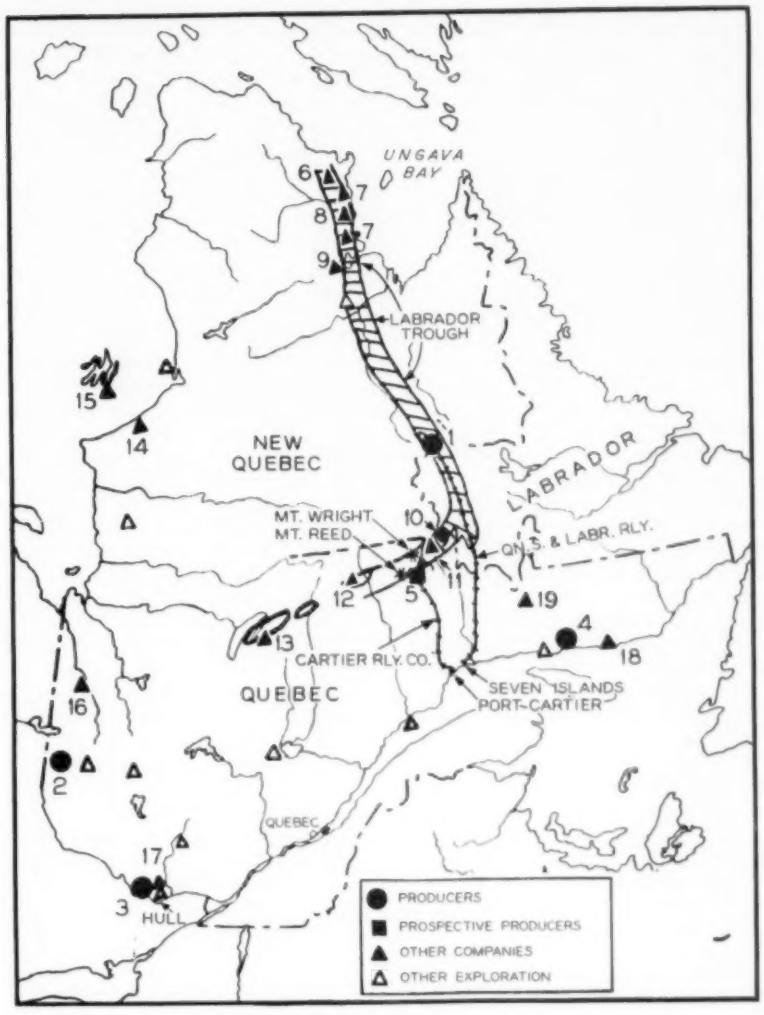
10. Iron Bay Mines Ltd.
11. El Sol Gold Mines Ltd.
12. Lun-Echo Gold Mines
13. Steep Rock Iron Mines Ltd.
14. Jalore Mining Co. Ltd.
15. Monpre Mining Co. Ltd.
16. Anaconda Iron Ore (Ontario) Ltd.
17. Mattagami Mining Co. Ltd.
18. Triana Exploration Ltd.
19. Multi-Minerals Ltd.
20. North American Rare Metals Ltd.
21. Frobisher Ltd.
22. Algoma Ore Properties Ltd.

a belt conveyor was installed from the pit. Many of the pits on the Mesabi Range at this time were becoming too deep for economical mining by rail haulage, and many track benches were tied up and unavailable for mining because railroad haulage was used. The ore in many pits already abandoned for open pit mining was made available for mining by the introduction of revolving shovels and truck haulage. Likewise, much of the ore considered as underground reserves was developed for open pit mining because of these innovations.

Another factor that contributed largely to an increase in reserves, particularly on the Mesabi, was the development of iron ore concentration. The first concentrator, built by Oliver Iron Mining Co. at Trout Lake in 1910, made available very large tonnages of sandy wash ores, which could be readily concentrated into high grade ores. The progress in concentration has continued far beyond the original washing plant. In 1957 there were in use in Minnesota 15 straight washing plants, 35 washing and heavy density plants, and one fine ore concentration plant using flotation. There is one washing and sintering plant on the Cuyuna Range which is used in beneficiation of high-moisture low-grade ores. In 1910 610,000 tons of beneficiated ore were shipped and in 1957 24,418,000 tons.

In Michigan there are two heavy density plants and two flotation plants in operation. There is also a drying, screening, and heavy density plant and pellet plant. The pelletizing plant is operating on flotation concentrates.

During the years following the depression of 1929-1933 iron ore shipment from the Lake Superior District lagged, and it was the general opinion of the steel industry that the Michigan, Wisconsin, and Minnesota reserves would be ample for the forseeable future. An estimate made in 1936 by various representatives of the steel companies placed the expected average yearly consumption at 40 million tons. On the basis of reserves at that date—estimated at 1.42 billion tons—there was a life of 35 years for these reserves. During the ten-year period 1931 to 1940 the reserves decreased by only some 50 million tons, while 337,384,000 tons were shipped during this period. Accordingly there was a net



Producers of Iron Ore
1. Iron Ore Co. of Canada
2. Noranda Mines Ltd.
3. Quebec Iron & Titanium Corp.
4. The Hilton Mines

Prospective Producers with Announced Production Plans
5. Quebec Cartier Mining Co.

Some Exploration and Development Companies
6. Quebec Explorers Ltd.
7. Ungava Iron Ores Co. Ltd.
8. Oceanic Iron Ore Co. of Canada Ltd.
9. Consolidated Fenimore Iron Mines Ltd.
10. Wabash Lake Area:
    Canadian Javelin Ltd.
    Julian Iron Corp.
    Labrador Mining & Exploration Co. Ltd. and Iron Ore Co. Ltd.
    Wabash Iron Co., Ltd.
11. Mt. Wright Area:
    Bellechasse Mining Corp. Ltd.
    Holannah Mines Ltd.
    Jubilee Iron Corp.
    Quebec Cartier Mining Co.
    Quebec Cobalt & Exploration Ltd.
12. Pletipi Lake—Matonipi Lake Area:
    Consolidated Morrison Exploration Ltd.
    W. S. Moore & Co.
13. Albanel Minerals Ltd.
14. Great Whale Iron Mines Ltd.
15. Belcher Mining Corp. Ltd.
16. Atlin Ruffner Mines (B.C.) Ltd.
    Lambton Copper Mines Ltd.
17. Jalore Mining Co. Ltd.
18. Aconic Mining Corp.
    Olivier Iron & Steel Ltd.
19. Halmon Mining & Processing Ltd.

gain in the reserves in the ten-year period on account of further development of 287 million tons. On the basis of these figures, the steel industry considered that reserves of the Lake Superior District were good for at least 50 years and that there was no cause for concern.

Beginning with World War II a very large increase in consumption of Lake Superior ore began, and many blast furnaces were built at the expense of the Government and by private enterprise to increase iron and steel capacity. During 1940 to 1949 inclusive, 781 million tons were shipped, or a yearly average of 78 million, approximately double the consumption of ore anticipated in 1936.

This increased production has continued over the years, and the iron and steel industry began to realize that the Lake Superior District could not continue to supply its increased requirements for many years into the future. The industry began to look around for other sources of iron ore.

Bethlehem Steel Co. continued to import large tonnages of iron ore from Chile for its Eastern Seaboard furnaces and also initiated development of a property near the Orinoco River in Venezuela. U. S. Steel Corp. developed very large ore reserves in Venezuela. Republic Steel Corp. went to Liberia for part of its ore requirements. Substantial tonnages of iron ore were also imported from Brazil and Peru.

Intensive studies of iron and steel metallurgy made during the past five years indicate that improved structure of the iron ore going into blast furnaces will result in lower costs and greatly increased furnace capacity. These studies have indicated that a sized blast furnace feed with as high an iron content as possible is desired. The natural ores of the Lake Superior District as mined are unsized, range in structure from 3 in. down to −100 mesh, and average 51.50 natural in iron. Lake Superior operators are working to improve the structure and iron content of these ores, and large investments also have been made in concentrating and agglomerating low grade taconite.

Recent Plant Expansion: During this postwar period attention of the iron and steel industry was turned to the magnetic taconites, known to exist on

the Mesabi Range, that had been partially developed and operated by Jackling at Babbitt, Minn., in the early 1920's.

The original Jackling plant had been operated on an experimental basis. Reserve Mining Co., owned by Republic Steel Corp. and Armco, took over the plant and leases owned by the Jackling interests and about 1950 began development of a large taconite enterprise. A railroad was built from the mine to Silver Bay on Lake Superior, and concentrating and pelletizing plants were constructed on the lake. Magnetic taconites are now shipped from the mine and are concentrated and pelletized at Silver Bay. The Silver Bay plant, which began operating commercially in 1956, has a capacity of 5 to 6 million tons of high grade iron ore pellets per year.

Pickands-Mather, as agent for Bethlehem, Youngstown, and others, likewise proceeded to develop magnetic taconites west of those controlled by Reserve, first building an experimental plant on the range and then a large concentrating and pelletizing plant at Hoyt Lakes, Minn. Experimental pellets were produced by Erie from 1953 until 1958, when the large plant, rated at 8-million ton capacity, was placed in operation. Erie also built a railroad to Lake Superior and a harbor and power plant east of Silver Bay at Taconite Harbor. Combined capacity of these two plants is 12 to 15 million tons of pellets per year.

U. S. Steel's Oliver Iron Mining Div., which controls large reserves of magnetic taconite on the Mesabi Range, has carried on extensive experiments in magnetic concentration of taconites at its Pilotac plant at Mountain Iron. Fines from this plant and screened fines from direct-shipping ores on the Mesabi have been sent to Extaca, Oliver's experimental agglomerating plant near Virginia. Although these plants are experimental, they produce about 1 million tons of agglomerated material.

Marquette Iron Mining Co., operated by Cleveland-Cliffs, has built a pelletizing plant of 650 thousand-ton annual capacity on the Marquette Range to handle flotation concentrates from the Republic mine. Another pelletizing plant is projected for the Marquette Range to handle flotation concentrates from the Humboldt property. This property is controlled by Cleveland-Cliffs Iron Co. and Ford Motor Co. and has been shipping flotation concentrate to Ford Motor Co. for sintering. The plant will be able to handle about 640,000 tons per year.

M. A. Hanna Co. is developing a low grade property at Randville, Mich., which will also produce flotation concentrates. Some of these concentrates will be shipped to furnaces for sintering, but it is expected that facilities will also be built for agglomeration at the mine. Projected capacity of this plant is 500,000 tons of concentrates per year.

Problems in Treating Underground Reserves: Modern furnace practice will have an important effect on ore reserves of the Lake Superior District. Total reserves of direct-shipping and easily concentratable ore estimated for the District as of Jan. 1, 1957, were 952 million tons. Underground reserves included in this total were 388 million tons.

Early availability of these underground reserves is questionable. In order to prepare direct-shipping ore for blast furnace consumption it is proposed to screen the material at about ½ in., using the coarse fraction directly in the blast furnace and sintering the fine fraction, but there are serious difficulties involved in separating the coarse and fine fractions in the underground ores. As a general rule, ores that are mined underground contain 10 pct moisture or more, and to dry-screen then it will be necessary to drive off part of this moisture.

There is considerable variation in analysis of the coarse and fine fractions of ore screened. Generally the fine fraction contains a material of higher grade and removal of the fine material produces a lower grade coarse fraction. If this lower grade coarse fraction is to be used it must undergo beneficiation, which would probably involve a heavy density process. All in all, sizing and beneficiating underground ores is a complicated and expensive process, and it is questionable that the economics of the situation will permit such treatment.

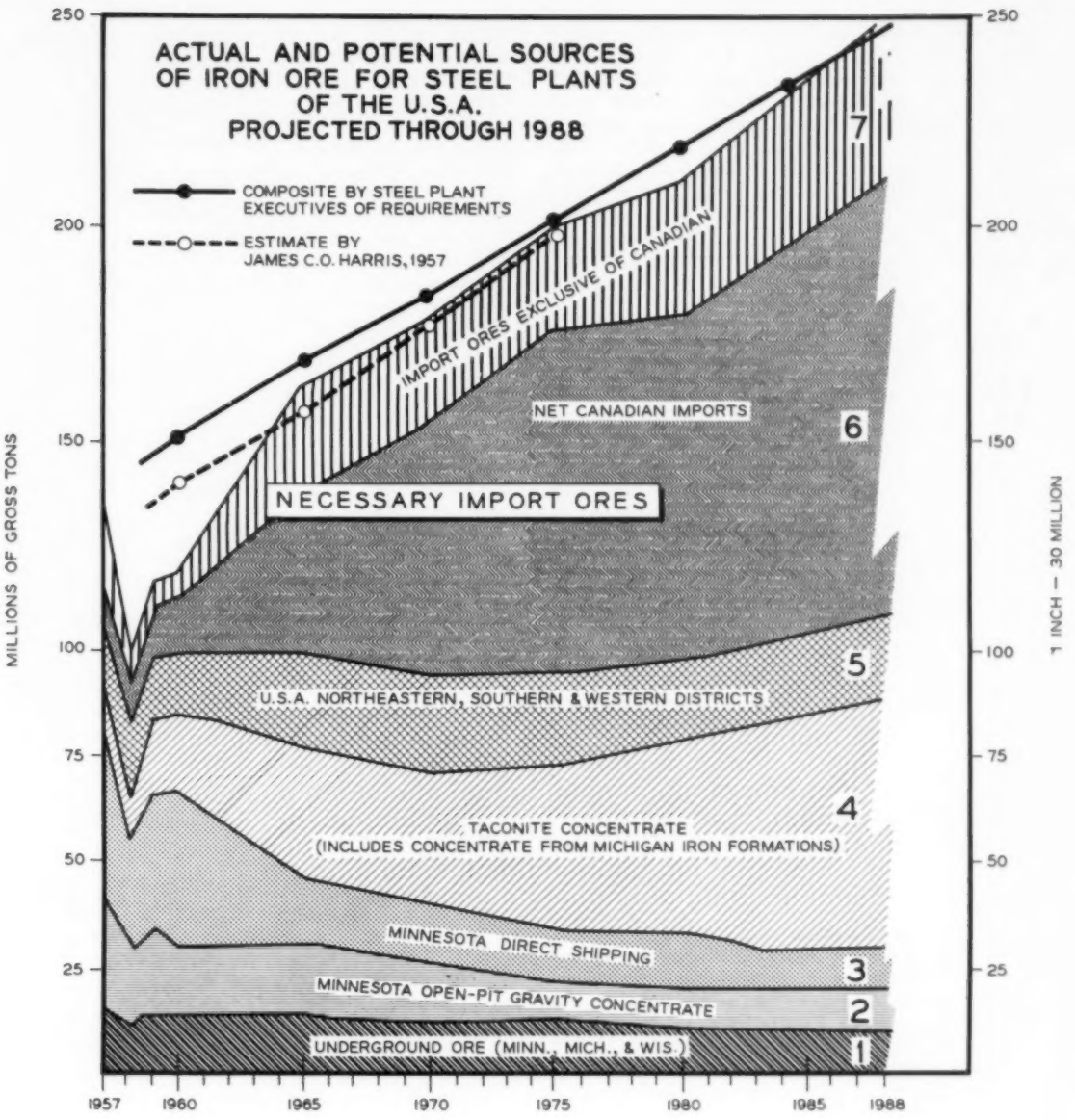
Open Pit and Underground Costs Compared: With reference to this problem, comparison of the open pit and underground mining costs is illuminating. In 1955, when the last figures were available, average mining cost, not including royalty, was $1.50 per ton of open pit ore mined in the Lake Superior District and $5.32 per ton of underground ore mined in the District. Since 1955 increasing labor costs have further spread the differential between open pit and underground mining, and it is quite evident that even without the addition of any cost for beneficiating underground ores, they are not at present competitive with the open pit ores. The open pit ores as produced are comparatively free of moisture and can be dry-screened for sizing without serious difficulty.

In any calculation, therefore, of total reserves available for mining in the Lake Superior District at the present time, a large part of the Minnesota underground reserves should be eliminated. Currently there are only five underground mines operating in Minnesota out of a total number of 42 listed underground reserves. It is not expected that these underground reserves will be operated in the foreseeable future. Minnesota's estimated reserves total approximately 790 million tons, of which about 30 pct are underground. Accordingly, this reserve figure should be reduced to about 555 million tons.

With the exception of the low grade properties, all the mines in Wisconsin and Michigan are underground. These mines are already developed and represent large capital investment, they produce ore of superior quality, and their shipping facilities offer advantages in freight rates. It is expected that they will continue to operate.

Discussion has so far been concerned with the reserves of direct-shipping ore and concentrates from the Lake Superior District and has dwelt only briefly on the plants operating on magnetic taconites of the Mesabi Range and low grade ores in Michigan. The reserves of these ores have not been fully considered.

Low Grade Ore Reserves in U. S.: The magnetic taconites on the Mesabi extend from the extreme east end to about the center of the range west of Mountain Iron, Minn. On the extreme east end the whole formation is magnetic, but going westward the magnetic formation is located on the footwall and is known as the lower cherty formation. The upper part of the formation in this area is not magnetic. It has been estimated that there is a total reserve of open pit magnetic taconite ores of ap-



proximately 5 billion tons of crude, equivalent to 1.7 billion tons of concentrates. Two commercial operations, the Reserve and Erie plants, are now producing magnetic ore from taconites. It has been stated that these two plants have a combined capacity of 12 to 15 million tons per year. The cost of these plants—including rail connections, power plants, and housing—was approximately $40.00 per ton of annual capacity or in the neighborhood of $500 million.

Since Oliver has recently acquired large reserves of more easily concentratable material, it is generally believed that the company will postpone development of its magnetic taconites on the Mesabi, but these still remain a potential reserve in the Lake Superior District.

If additional ore is to be produced from the magnetic taconites, more plants must be built. With the very high capital investment involved it seems doubtful at this time that capacity will be increased in the near future. At the current rate of producing magnetic taconites, reserves of this ore will last for more than a hundred years.

The magnetic taconites as produced by Reserve Mining Co. during the past three years have become competitive with the underground ores in the Lake Superior District. During 1958, when consumption of Lake Superior ores decreased sharply, pellets from magnetic taconites were sold on the open market as a distress measure at the same price as the Old Range direct-shipping Lake Superior ores.

In addition to the Mesabi's magnetic taconites, there are known deposits of magnetic iron formation in Wisconsin which have been partially developed. These are quite similar to the magnetic taconites and are amenable to the same concentration and pelletizing process. Reserves of these ores are presently estimated at 263 million tons of concentrates.

There are also the low grade ores of the Marquette and Menominee ranges which are being developed at the present time. As mentioned pre-

viously, Marquette Iron Mining Co. is operating the Republic mine and a pelletizing plant on the Marquette Range and producing high grade pellets from concentrates. Likewise, the Humboldt mine has been developed to produce flotation concentrates heretofore used as sinter feed by the consumer. To pelletize these concentrates a plant will be constructed on the Marquette Range, where other deposits of treatable low grade ore are known to exist. A rough estimate of the present reserves of ore which can be concentrated by flotation on the Marquette and Menominee ranges is 300 million tons of concentrates.

Finally, there are large tonnages of lean ores in the Mesabi, Gogebic, Marquette, and Menominee ranges which are amenable to concentration by magnetic roasting and magnetic concentration. At present this process is not commercial, but if natural gas were available at reasonable cost, some of the lean ores of higher grade would immediately become merchantable by this magnetic roasting and magnetic concentration. Efforts have been made over the past 15 to 20 years to secure such supplies of natural gas for Michigan and Minnesota for concentration of these low grade ores. The tonnages that would be available are very large.

In the Lake Superior District the following reserves of iron ore would be available:

Estimated Reserves	Tons
Open pit ore	564,000,000
Underground ore	388,000,000
Total, direct-shipping or readily concentratable ores	952,000,000
Magnetic taconite concentrates	1,700,000,000
Wisconsin magnetic iron formation concentrates	263,000,000
Michigan low grade ore concentrates	300,000,000
Total	3,215,000,000

Future of Canadian Reserves: In recent years a constant and intensive search has been made for iron ore in Canada which could replace the dwindling reserves of the Lake Superior District and would not be subject to the hazard of shipping during war times.

Developments in Canada over the past 20 years have added to these reserves. The Michipicoten District, discovered many years ago, produced some direct-shipping ore from the Helen mine for Algoma Steel Corp. This direct-shipping ore was exhausted, but in 1936 active development of a large deposit of siderite at the Helen mine was begun. This property began shipments of a manganiferous sinter in 1939 and has continued from that date to the present. This mine, the Victoria property, and others in the area will no doubt continue to produce substantial tonnage of this ore in future years. No reserve estimate is available of the tonnage in these properties.

The year 1942 marked initial development of the Steep Rock mine near Atikokan, Ont. Placed in operation in 1945, the mine has been a substantial producer ever since. It is operated by Steep Rock Iron Mines Ltd. Part of this deposit has been leased to Inland Steel Co. (known as Caland in Canada), and it is expected that this company will begin producing iron ore in 1960. These two operations will be capable of producing 5 to 10 million tons per year, and reserves are estimated at 300 million tons.

In 1929 iron ore was discovered in the Labrador trough which straddles the boundary line of Quebec and Newfoundland. In 1949 the Iron Ore Co. of Canada was formed by the Hanna Coal & Ore Corp. with the participation of several American steel companies. This company, in association with Hollinger, proceeded to develop these direct-shipping orebodies, constructing a 360-mile railway to the properties from Sept Iles on the Gulf of St. Lawrence. An iron ore loading dock was built at Sept Iles and hydroelectric power was developed near the mines. The first iron ore was shipped from the properties in 1954 and large shipments have continued since that date. The total shipments in 1957 were 12,450,000 tons. Most of this ore goes to steel companies in the U. S., but some is exported to Europe. No estimate of ore reserves in these properties is available.

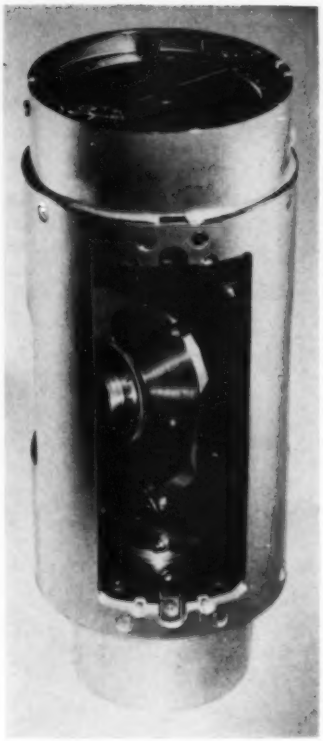
Development has now begun on many low grade properties discovered in Canada which will require concentration and agglomeration. Most of these properties are located in the extension of the Labrador trough both north and south of the discovery of high grade ore described above. To the extreme north developments have shown the presence of concentrating ore along Ungava Bay. South of the Iron Ore Co. of Canada holdings the Labrador trough turns to the southwest, and concentrating ore in large quantities has been discovered in this southwesterly extension. U. S. Steel Corp. has already undertaken development of a property at Mt. Reed on this extension, which contains a very large tonnage of concentrating ore. The property will go into operation within the next few years and is expected to produce 8 to 10 million tons of ore per year.

It is now believed that Canada can supply the loss of tonnage resulting from depletion of the Lake Superior District ores.

Accompanying this report is a chart showing estimated requirements of iron ore in the U. S. over a period of 30 years beginning with 1957, and the sources from which such requirements will be met. This chart was prepared by Verne D. Johnston of Oglebay Norton & Co. and the estimate of requirements has been made by several prominent steel executives. The chart shows a continued and rapid growth of the steel industry in the U. S. It will be noted that the underground production from the Lake Superior District continues almost in a horizontal line over this period. There is rapid depletion of the Minnesota open pit direct-shipping and gravity concentrates, and a rapid increase in production of taconite concentrates.

Cost per unit of plants for producing taconite concentrates is very high, and it is doubtful that taconite production will increase as rapidly as shown on the chart. The balance of reserves required for the steel industry will have to come from Canadian and other foreign imports. Recent developments in Canada indicate that reserves may be developed which will support this rapid growth of production. Iron ore is being very widely discovered both in Africa and South America, and no doubt the tonnages shown on the chart from imports, exclusive of Canada, can be met over the period. These imports, however, are subject to the hazards of shipping, which make them undependable in case of a national emergency.

Discussion of this article sent (2 copies) to AIME before June 30, 1959, will be published in MINING ENGINEERING.



GYRO-COMPASS SURVEYS UNDERGROUND WORKINGS AND BOREHOLES

by EUGENE P. PFLEIDER and OTTO RELLENSMANN

For many years mine surveyors and exploration engineers have sought an accurate means of transferring meridian underground by using the gyro-compass. These efforts have generally failed, either because they were inaccurate or because the size and cost of the unit were prohibitive. During the past ten years, however, great strides have been made. Autonetics in California has developed a comparatively light-weight (100-lb) gyro-theodolite, and the Institute for Mine Surveying at Clausthal Mining Academy in Germany has developed an instrument that is accurate to within 20″ to 30″ of arc. Concurrently, Minneapolis-Honeywell has produced an astounding gyro, the size of a salt shaker, that weighs less than 0.5 lb and compares favorably in performance with the 50-lb gyros of conventional design. This unit, designed for missile guidance, should be adaptable for surveying small boreholes. Given the proper interest and approach from the engineering fraternity, excellent gyro-compasses could probably be available for accurate underground survey work at nominal cost within the next three years.

E. P. PFLEIDER, Member AIME, is Professor and Head, Division of Mineral Engineering, School of Mines and Metallurgy, University of Minnesota, Minneapolis. O. RELLENSMANN is Professor, Clausthal Mining Academy, Clausthal-Zellerfeld, West Germany. Manuscript, Dec. 8, 1958. TP 4798A. AIME Trans., Vol. 214, 1959.

Principles of the Gyro-Compass: The gyro-compass, used for 50 years as a navigational instrument in ships and aircraft, senses the turning axis of the earth and points out true polar north. It does this by employing the earth's rotation, the force of gravity, and the precession characteristics of a gyro. For further details the reader is referred to several excellent publications[1-5] covering the principles and application of the gyroscope.

The heart of the gyro-compass is the gyroscope, or rapidly spinning wheel, which rigidly maintains its angular orientation in inertial space. Free gyros employ universal joints to allow the wheel axle to maintain its rigid spatial orientation independent of base motion disturbances. Free gyros are independent of the earth's turning and are not north-seeking. Only as they might be initially oriented parallel to the earth's turning axis could any north indication be obtained. In practice, the free gyro tends to drift off its set position and lose its accuracy.

The Sperry-Sun Well Surveying Co. instrument (5½ in. O. D.) is of this free gyro type. It is counterbalanced, however, against the rotational effects of the earth, so that orientation of the spinning axis will be maintained throughout the survey.

Now, if a force is applied to one end of the spinning axis A-A′ in a direction parallel to C-C′, the primary response is the turning of the wheel assembly about axis C-C′. This effect, called *gyro-precession*, is explained by the mechanics of conservation of angular momentum. Conversely, turning rates around vertical axis C-C′ develop a proportional torque and angular deflection around axis B-B′. These angular deflections may be converted into electrical signals by a pick-off device, or a torquer or precession motor can be used to generate control torques on axis C-C′. The Honeywell gyro-compass, described later, employs this technique.

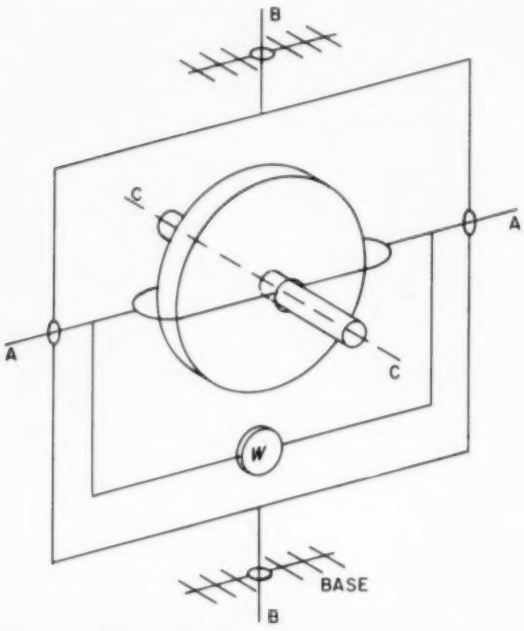


Fig. 1—The three-frame gyroscope with pendulous unbalance added to make it north-seeking. (After Lower).

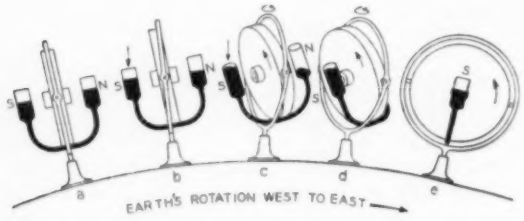


Fig. 2—Gyro-compass, mercury in U-tube. (Lower)

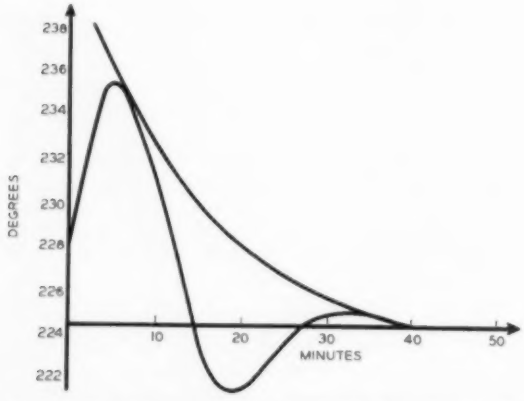


Fig. 3—The dampened swing cycle of the gyro-theodolite is shown on the above graph. (After Ludemann).

The mechanization of the conventional north-seeking gyro-compass departs from the free gyro concept and couples the earth-turning rate into the gyro. These earth rates precess the gyro and align its axle in a north-south direction. Lower[4] describes the gyro mechanization that will find north. He says, with reference to Fig. 1:

> Assuming the gyro axle to be at a random position off of north as it is started, the gyro rigidity in space will necessitate a tilting about axis A-A as the earth turns. But pendulous weight W tends to maintain the gyro axle in a horizontal orientation. This effect couples a spatial turning rate into the A-A axis and results in a precession of the assembly about axis B-B, in keeping with the basic principles of the gyro. This process will continue until the gyro axle is pointed north; at this unique orientation the earth's turning no longer results in tilting the gyro axle against the restoring pendulum. Fig. 2 serves to illustrate this process of a gyro-compass action using mercury in a U-tube as the pendulum.

The Clausthal gyro-theodolite employs this principle, using lead ballast as the pendulum.

Basic Factors: The accuracy and oscillatory characteristics of a gyro-compass in its seeking and holding of true north depend on several important factors:

1) The extremely low frictional restraint in all movements.

2) The magnitude of the meridian direction moment, R (or the torque developed around the vertical axis in its seeking of north direction).

This is dependent on the angular momentum of the gyro wheel, the earth's turning rate, and the latitude, as expressed by Eqs. 1-3:

$$K = I\,\omega\,\Omega \qquad [1]$$

$$R = \frac{K \cos \phi}{g} \cdot \sin \alpha \qquad [2]$$

$$R = \frac{I\,\omega\,\Omega \cos \phi}{g} \cdot \sin \alpha \qquad [3]$$

Where K = full directional torque developed by gyro at equator, dyne-cm.

R = meridian direction moment at latitude ϕ, gr-cm.

I = moment of inertia of gyro, gm-cm^2.

ω = angular velocity of gyro, radians per sec.

$I\,\omega$ = angular momentum of gyro, gm-cm^2 per sec.

Ω = angular rate of precession of gyro (or rate of turn) around horizontal axis, due to earth's revolving, radians per sec.

$$\frac{2\,\pi}{23.93 \times 60 \times 60} = 0.0000728 \text{ radians per sec.}$$

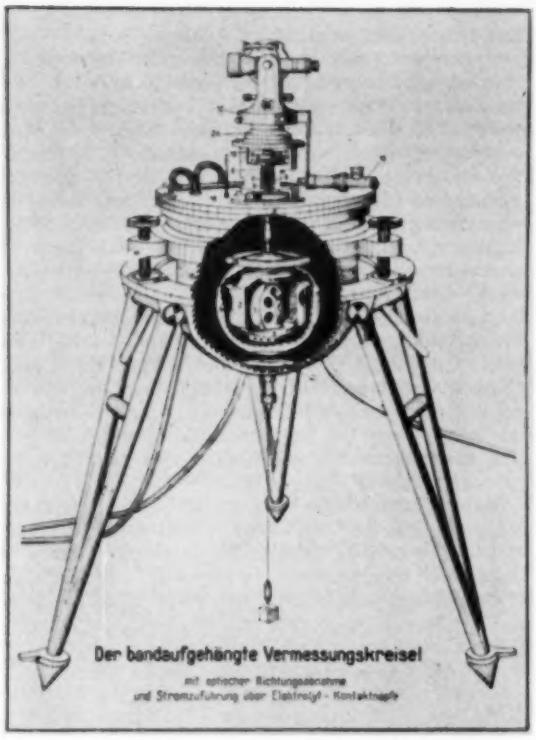


Fig. 4a—Insert shows the suspension of the gyro in earlier model of theodolite developed at Clausthal.

ϕ = latitude of observation, wherein only one half the available torque developed by the gyro would be applied at a latitude of 60° (cos 60° = 0.5).

g = acceleration of gravity, cm per sec^2, dependent on elevation and latitude. Equal to 980 cm per sec^2 at sea level and equator.

α = amplitude of precession from north, degrees.

3) The natural period of the compass, T, i.e., the time it takes to perform a complete oscillation of the gyro-compass about the meridian, as shown in Fig. 3.

This is dependent on the magnitude of the full directional torque, K, the weight of the pendulum, the latitude, and the metacentric height, as expressed by Eq. 4:

$$T = 2\pi \sqrt{\frac{K}{mga\ \Omega \cos \phi}} \qquad [4]$$

T = natural period of gyro-compass, sec

m = mass of pendulum, grams

a = metacentric height equal to distance between point of suspension and center of gravity, cm.

4) The proper damping of the oscillatory swings of the gyro-compass.

Various techniques are used to dampen the oscillatory swings on each side of the meridian. The Clausthal-designed instrument can achieve high accuracy after about 30 min warm-up and 9 reversals of 13.5 min each (for half pendulum time), or a total of 2.5 hr at latitude of Clausthal. Fig. 3 illustrates the damping characteristics of a compass having a 66 pct damping factor, i.e., from 30° to 10° to 3 1/3° to 1 1/9° for the first four half-oscillations.

5) The maintenance of a constant rotational speed of gyro and a constant temperature of the liquid in which the gyro sphere is floated.

These points are highlighted in Table I, a comparison of the basic design factors of the Clausthal precision gyro-theodolite, used for accurate surveying underground, and the Miniature Integrating Gyro of Honeywell, considered for borehole surveying.

CLAUSTHAL GYRO-THEODOLITE

The accurate meridian-indicator,[5-7] manufactured by the instrument firm of Otto Fennel-Söhne of Kassel in West Germany, was developed for underground surveying by Otto Rellensmann and his associates at Clausthal Mining Academy. A heavy version of the instrument is illustrated in Fig. 4a and a new smaller version in Fig. 4b. The latter weighs 76 lb: instrument, 28 lb; tripod, 16 lb; transistorized generator, 12 lb; and batteries, 10 lb.

Construction: Design of the instrument utilizes the gyro mounted in a sphere by a bracket. A mast passing through the sphere is attached to the bracket and has a mirror at its upper end. The motion of the mirror, which represents the horizontal pre-

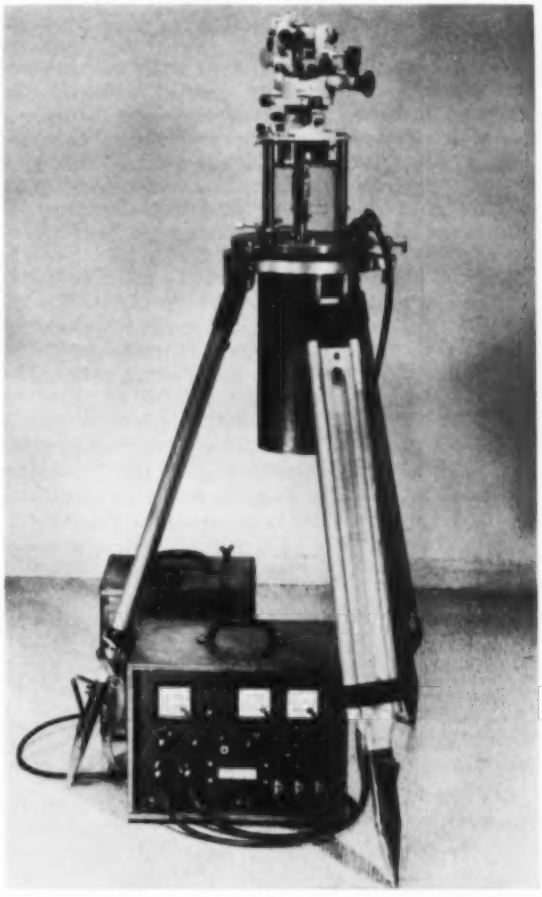


Fig. 4b—The Clausthal Academy KT-1 gyro-theodolite.

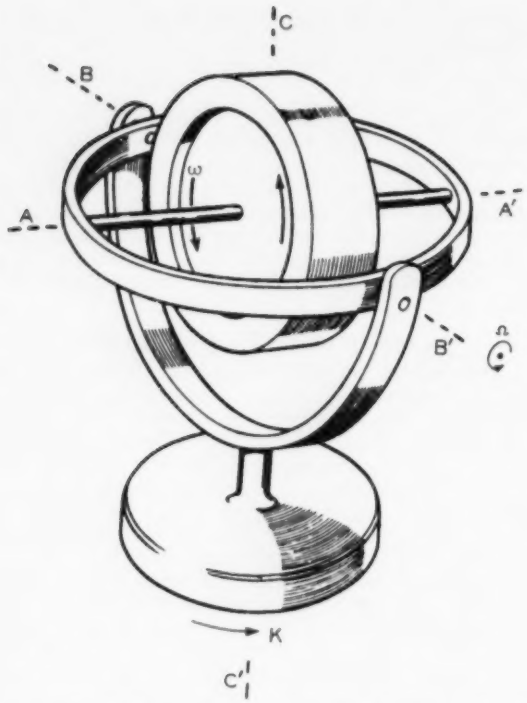


Fig. 5—A two-frame "rate" gyroscope showing relation between angular rate of precession, Ω, and resulting torque, K_r, as applied to gyro-compass. (Richardson).

cession of the gyro, is followed with an auto-collimation telescope attached rigidly to the alidade axis of the theodolite. The gyrosphere is hung by a metal band fastened to the end of the extended alidade axis. To reduce weight on the band to only 200 g, the gyrosphere floats in a water-filled gyro-container, a construction permitting the use of a fine metal band that has minimum torsional resistance to gyro swings. A sphere of Mu-metal on the inside of the container guards the gyro from influences of magnetic fields. The gyro wheel forms the rotor of a three-phase, 333-cycle asynchronous induction motor revolving at 20,000 rpm. Depending on availability or mine safety regulations, the generator providing the driving current may be powered by a 24-v, d-c battery-driven motor; a 220-v, a-c motor; or a compressed-air turbine unit. The instrument is transported in a special spring-mounted frame, with the gyrosphere clamped by two rings.

Table I. Fundamental Properties of the Clausthal Gyro-Theodolite and the Honeywell Miniature Gyro

		Gyro-Theodolite	Miniature Gyro
I =	Moment of inertia, gm-cm²	4.3×10^4	40
ω =	Angular velocity of gyro, rpm	20×10^3	24×10^3
	Angular velocity of gyro, rad./sec	2.1×10^3	2.5×10^3
$I\omega$ =	Angular momentum of gyro, gm per cm²/sec	9×10^7	10^5
K =	Torque, dyne-cm	6.5×10^3	7.5
R =	Meridian direction moment, gm per cm at Clausthal, Germany—latitude 51° 19'	4.9	4.66×10^{-3}
	at Kiruna, Sweden—latitude 67° 42'	2.97	2.82×10^{-3}
T =	Natural period of gyro-compass, minutes at Clausthal	27	
	at Kiruna	34.6	
W =	Weight of gyro assembly, lb	50±	0.5
D =	Diameter of gyro, in.	5.3	
	Diameter of gyro assembly, in.		1.75

Operation: After the instrument is centered and leveled, the swinging of the gyro is followed continuously by observing the mirror through the auto-collimation telescope. At the same time, the torsion moment of the band is compensated by regulating the zero position. In this manner only the direction moment of the gyro is effective. At least three reversing points and probably more, depending on the accuracy desired, are read in order to calculate the north direction. The angle between the calculated north direction and the measured line is corrected by a constant of the instrument, which is determined by checking with the bearing of an accurate base line. If the base line is part of a geodetic system, the convergence of the meridians must be worked out and incorporated into the calculations. Generally, the constant of the instrument is checked by base line measurements both before and after an important series of observations.

Many checks have been made between well established base lines surveyed by astronomic methods and by the gyro-theodolite. The average error of an individual measurement is about 20″ of arc. An order of accuracy of 30″ can be assumed for most work.

Two gyro-theodolites in constant use in the Ruhr coal district are operated under the direction of the Gyro-Measuring Station of the Bochum Mining School at Bochum, Germany. Extensive measurements have also been made at the Kiruna iron mines and the Boliden base metal properties in northern Sweden with good results. Otto Fennel-Söhne manufactures the instruments now in use, copying the prototype developed at Clausthal.

Application: Since the gyro-theodolite measures angles from astronomic north, it is particularly useful for orienting underground surveys. Operating independently of other methods, it provides a check on previous surveys.

Accuracy of a conventional traverse decreases with the length and number of angles measured. The gyro-theodolite can be used to check the direction of any line in the traverse. Even in the case where the underground survey is connected with the surface traverse through two shafts, accuracy depends on distance between the shafts, length of traverse, and number of angles. The methods currently employed for transfer of directions from surface to underground depend on many local conditions, such as condition of shaft, depth, air currents, dripping water, magnetic influences, and hoisting operations. Many of these difficulties can be eliminated by suitable application of the meridian-indicator. Other uses for this instrument include surveys for geographers, cartographers, and geologists and inertial guidance for control of automatic mining machines.

AUTONETICS GYRO-THEODOLITE

A counterpart to the German theodolite has been produced by Autonetics, a division of North American Aviation, under the name of ABLE (Fig. 6). Weighing less than 100 lb, it is powered by either 115 v, single or three-phase current, at 60 or 400 cycles a-c, or by 28 v, d-c, at 125 w. Alignment time is 15 min at 30° latitude and 30 min at 60° to 70° latitude.

The ABLE system[3] consists of a high-quality

rate-measuring gyro coupled with an electromechanical arrangement for providing a signal proportional to the space rate of rotation of the gyro about its *input* axis. As the gyro tends to precess, a pick-off device senses a minute displacement and produces an electrical restraint or torque that prevents rotation and also indicates the magnitude of the required restraint. Internal bias torques are compensated for by the technique of completely reversing rotor rotation. Hence the resultant torque supplied by the electrical restraint is the only torque acting. This torque, shown by the indicator, is proportional to the input axis misalignment with respect to east-west.

In operation, the gyro is aligned by increments until the component of the earth rate lying along the gyro input axis is zero. At this point no restraint is required, the indicator shows null, and the north-south baseline is established.

All circuits for operation are transistorized, and plug-in cards provide for easy replacement of individual units. Provisions for rapid circuit checks are included so that marginal operation or malfunction is easily detected. The gyro and mirror

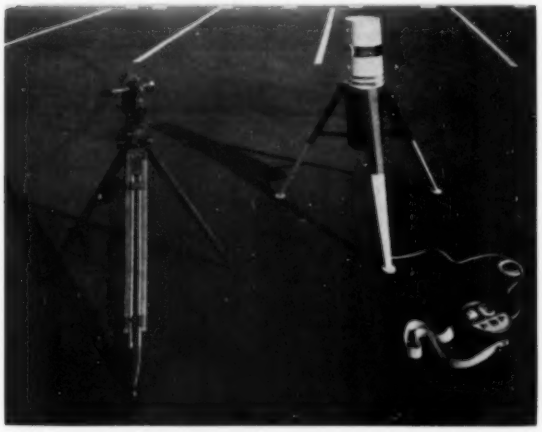


Fig. 6—The ABLE gyro-compass base line equipment.

assembly, or any of the plug-in cards, can be replaced in the field in a matter of minutes.

SURWEL GYRO-COMPASS FOR BOREHOLES

Boreholes having casings of 6⅝ in. O.D. or larger have been surveyed successfully for the past 25 years in both the mining and petroleum industries, using the Surwel well-surveying instrument equipped with a Sperry gyro. The instrument employs the free gyroscope," a plump bob type of angle unit, and a 16-mm camera. The protective casing is 5½ in. O.D. The free gyro is counterbalanced against the rotational effects of the earth, so that orientation of the spinning axis will be maintained throughout the course of the survey.

A gyroscopic direction indicator is attached to the top of the gyro's vertical axis, and a cross-hair plumb bob type of angle unit is mounted directly above the gyro to show the inclination of the hole. Directly under the gyro direction indicator is a tracer watch, which is synchronized with a surface watch. These three essential factors of direction, inclination, and time are superimposed on a background of concentric circles and recorded intermittently, at predetermined time intervals, on 16-mm

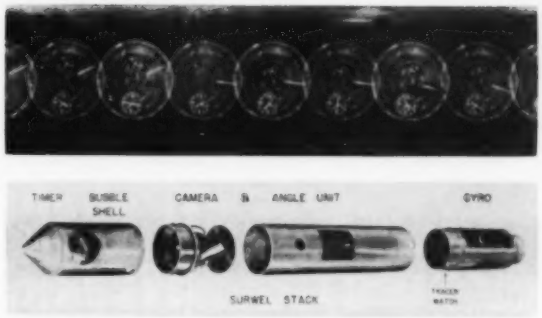


Fig. 7—Camera records of drillhole survey by Surwel. The Surwel multishot instrument is illustrated below.

continuous strip film. By using a time-depth log, the photographic reproduction of the time shown on the tracer watch indicates the depth at which each individual exposure is made. A group of photographic recordings is illustrated in Fig. 7.

Since orientation of the gyroscopic direction indicator is determined at the beginning of the survey, and is maintained throughout, the subtented angle between the direction indicator and a line drawn from the center of the inclination circles through the cross hairs gives the true bearing of the hole direction. The Surwel instrument is lowered on a wire line, and stop times of only half a minute are required for each record. Film capacity is sufficient to survey the deepest wells, both in lowering and with a check set of readings upon pulling out of the hole.

As to accuracy, the bottom hole coordinates of two gyroscopic surveys (one made going into the hole and the other coming out) generally will not vary more than 0.1 to 0.2 pct of the depth for the holes inclined less than 10° to 15° from the vertical. Comparable closures for holes of flatter inclination are likely to be greater.

HONEYWELL MINIATURE GYRO-COMPASS

Conventional gyro-compasses employ large gyro wheels, spinning at rapid rates, to obtain the gyro forces and torques required for performance accuracy. Relatively low frictional restraints are obtained by floating the gyro ball and using a system of small torsion wires. The result is an instrument weighing 50 lb or more, one far too large to fit into a small diamond drill hole. Further, the free gyro type of well-surveying equipment,

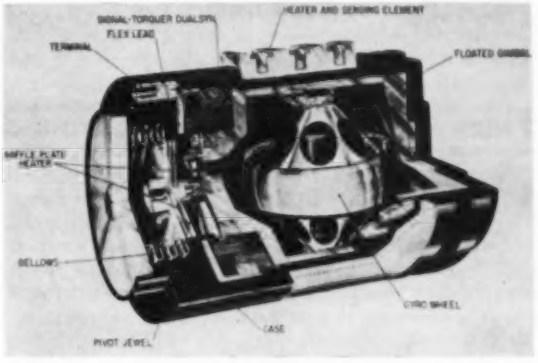


Fig. 8—Honeywell miniature integrating gyro. (Lower).

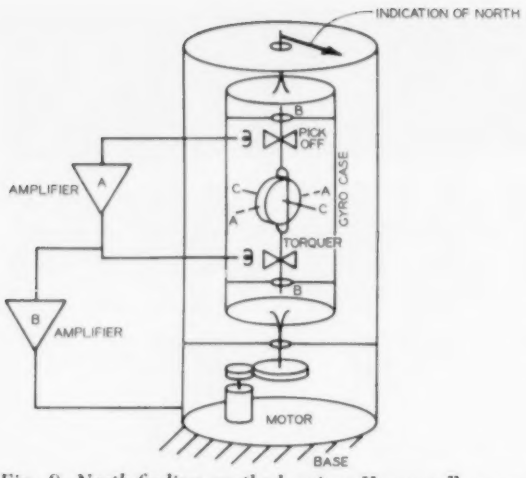


Fig. 9—North-finding method using Honeywell gyro.

such as the Surwel, is too large for use in small boreholes of 2 to 3 in. diam.

A new Honeywell miniature gyro with associated electro-mechanical equipment finds north by a technique somewhat different from that used in the conventional gyro-compass. As a consequence, it has promise of size reduction to 3 in. diam or less and may be a candidate for diamond drill hole exploration. The instrument, as described in detail by Lower,[4] is shown in Fig. 8. Although it is only 1.75 in. diam and 0.5 lb in weight, its sensitivity permits finding north to a fraction of a degree in most latitudes. This gyro sensitivity results from the greatly reduced frictional restraints realized by floating the gyro's moving element in a special heavy viscous fluid called Fluorolube. The gyro wheel (Fig. 8) spins in an inert gas within the floated gimbal, which is positioned by watchmaker-type pivots and jewels. Friction levels of about 0.01 dyne-cm are achieved. Since the gyro wheel momentum is 10^5 gm-cm^2 per sec, about 7.5 dyne-cm torque is developed for the earth's turning rates of 15° per hr. Hence high gyro-compass sensitivity has been made practical in a very small package. Furthermore, the distributed support afforded by the fluid makes for a very rugged instrument, capable of taking shocks and field use.

Fig. 9 illustrates the method of finding north. Any component of the earth's rate coupled into axis A-A will develop a torque about B-B and start to displace axis B-B relative to the gyro case. Such displacement causes the pick-off to generate a signal that is amplified by amplifier A to drive the torquer. Electrical input to the torquer is a measure of the earth's turning rate into axis A-A; when such rates are zero, axis A-A must have a unique east-west orientation. A second amplifier, B, would actuate a motor and gear train to turn the gyro case, thereby automatically making this rate settle out to zero. At this condition, the gyro case will be indicating polar north.

To log the direction and inclination of the drillhole, it will be necessary to correlate data from a pendulum or plumb-bob device to the gyro-compass data. Various solutions to this general problem are now in use, such as punching a disk by a plumb-bob tip. Possibly newer methods may be required to complement the miniature gyro-compass approach.

Accuracies to be expected from this new approach can only be surmised. As with the Surwel unit, it seems clear that the closures of surveys would be inversely proportional to departure of the hole from the vertical.

Summary: The gyro-compass is being perfected in accuracy, as well as miniaturized, to a point where mining and civil engineers should consider its application for certain phases of underground surveying. The gyro-theodolite, as developed at Clausthal Academy and now available both in Germany and the U. S., can determine or check bearings of lines to approximately 30″ of true direction when related to polar north. This is generally better than the accuracies obtained when bearings are taken underground by conventional wire methods through single shafts. Unfortunately the cost of the instrument is high, and only major companies operating several groups of underground mines could justify the purchase. In order that the smaller operator may have access to such a method for checking important surveys, it is suggested that the U. S. Bureau of Mines, or some mining supply or service company, have several gyro-theodolites available throughout the U. S. on a rental basis.

Relative to gyro well-surveying equipment, the Sperry-Sun Surwel unit has been doing a commendable job for years in both the oil and mining industries. However, the drillhole must have a casing size of 6⅝ in. O. D. or greater. This excludes the unit in surveys of diamond drill holes as used in mining, for which the NX hole at about 3 in. O.D. is the largest size employed. The magnetic compass is satisfactory for determining the direction of inclination if the hole is not cased or if rocks are nonmagnetic. Where this condition does not obtain, there is no satisfactory method of determining bottom coordinates, and there has been much interest in developing a gyro-compass package of 2 to 3 in. diam. The new Honeywell miniaturized gyro offers hope that a practical gyro-compass for small boreholes will be available.

Full development and use of these new surveying methods, employing the gyro-compass principle, are directly dependent on the interest of the world's mining and exploration drilling industries.

The authors thank Sperry-Sun Well Surveying Co., Autonetics, and particularly J. W. Lower, gyro section chief of Minneapolis-Honeywell, for their valuable contributions and permission to publish data on their respective instruments.

REFERENCES

[1] K. I. T. Richardson: *The Gyroscope Applied.* Philosophical Library Inc., New York, 1954.
[2] Sperry Gyroscope Co.: *Gyro-Compass and Gyro-Pilot Manual,* 1949.
[3] H. F. Banks: The Gyroscope in Mining. *Colliery Engineering,* London, October 1950, pp. 397-404, and November 1950, pp. 453-456.
[4] J. W. Lower: Gyro-Compass Principles and Possible Adaptation to Surveying of Small Bore Holes. *Proceedings,* Seventh Annual Exploration Drilling Symposium, University of Minnesota, 1957, pp. 100-104.
[5] O. von Rellensmann: Der Vermessungskreisel, heutinger Stand und Weiterentwicklung. *Freiberger Forshungshefte,* January 1957, pp. 5-13.
[6] J. von Ludemann: *Entwicklung sarbeiten zum bandaufgehangten Vermessungskreisel.* Thesis presentation, Clausthal Mining Academy.
[7] O. von Rellensmann and F. J. Oertgen: *Der Einstaz des bandaufgehangten Vermessungskreisels im nordschwedischen Erzbergbau.*
[8] M. E. Campbell: ABLE—A Portable High-Accuracy Gyrocompass. *Proceedings,* Second National Convention of Military Electronics, Institute of Radio Engineers, Washington, D. C., June 1958, p. 290.
[9] A. B. Palmer, Sperry-Sun Well Surveying Co.: Personal communication, June 16, 1957.

Discussion of this article sent (2 copies) to AIME before June 30, 1959, will be published in MINING ENGINEERING.

RECENT DEVELOPMENTS IN PEBBLE MILLING

by BUNTING S. CROCKER

Pebble grinding was used at Lake Shore Mines in 1949. A full description of experimental evidence and test plant results was published in 1952[1] and further operating details in 1954.[2] In more recent years the term *autogenous grinding* has been coined and is now frequently seen in the technical literature. Autogenous crushing and/or grinding covers any grinding mill in which the larger pieces of ore are made to grind the fine pieces; the crushing and grinding may be either dry or wet. This discussion deals only with wet autogenous grinding, and only in the fine grinding part of the circuit, i.e., from 6 mesh to 92 pct −325 mesh.

The term *pebble milling* could apply to fine autogenous grinding in which the pebbles are made from the ore itself, or it could also refer to grinding with pebbles, such as flint pebbles, from a source outside the mine.

The first mill to use *screened* ore to grind the ore (1949) was Lake Shore Mines, Kirkland Lake, Ont. Pebbles were screened from the jaw crusher discharge and used in 5x16-ft tube mills which had been converted to 6 ft 8 in. by 16-ft grate discharge pebble mills. The same general practice was adopted the following year by the Wright-Hargreaves Mine in Kirkland Lake. Shortly after that the Neptune Mines in Nicaragua started correspondence with the writer concerning the possibility of using screened ore for grinding in their plant. They first ran some plant-scale tests which confirmed the Lake Shore findings, with the ultimate result that their plant was successfully converted in 1956 to an autogenous grinding plant.

In 1957-1958 the writer was successful in converting the grinding plant of Renabie Mines in northern Ontario to autogenous grinding. In all these plants the existing grinding equipment was converted, usually by expanding the diameter of the shell to make the change from steel grinding to ore pebble grinding mills. In all the above plants primary grinding was done in either small rod mills or ball mills. These mills first reduced the pebble mill feed to about 6 mesh. The final grinding in the pebble mills varied from 75 pct −200 mesh to 92 pct −325 mesh. At Lake Shore three stages of pebble milling were used, with a different size pebble in each stage.

In other parts of the world interest was being shown in this form of grinding, and in March 1952 the writer had some correspondence with the mill staff at Outokumpu in Finland, with regard to the pebble system used at Lake Shore. At Stockholm in 1957 the account of the crushing and grinding system at Outokumpu was presented in a paper by H. Tanner and T. Heikkinen.[3] This is the only ore grinding plant that does not use grate discharges on its pebble mills; trunnion discharges equipped with heavy reverse spirals retain the pebble load.

The first new mill designed to use screened ore as a grinding medium was the Bicroft mill at Bancroft, Ont., which began operation in the fall of 1956. In 1957 this plant was followed by similar installations at Faraday Mines, also in the Bancroft area, and the North Rankin Nickel Mines in the North West Territories. In 1958 the Dyno Mill at Bancroft was converted, using the same type of grinding. Since all these plants, designed by Kilborn Engineering (1954) Ltd., were originally planned as pebble grinding mills, they were able to take full advantage of the latest design and technique. They are neat in appearance and very efficient and easy to operate.

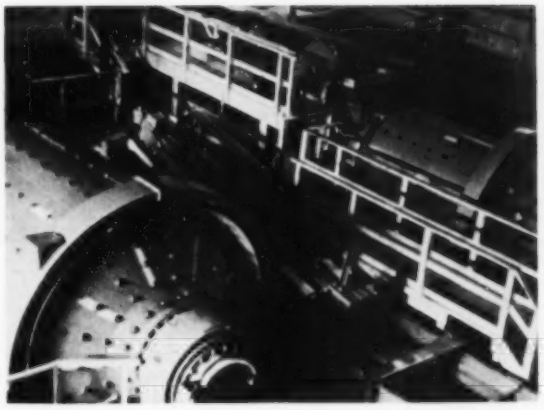


Fig. 1—One of the two grinding units at Bicroft Mines. The pebble mill is shown at left, the rod mill at right.

Effect of Ore Hardness: It is often commented that this type of autogenous grinding applies only to hard siliceous ores. Experience has shown that this is not so. In the past ten years the author has had an opportunity to test more than a dozen ores, several of which were quite soft. One of these was shale. The softer ores actually make better looking pebbles than the hard ores. These soft ores produced no particles in the intermediate size range which could not be ground by the largest pebbles in the mill charge. Slabby ores, such as shales, make a suitable pebble for the −6 mesh grinding. It is not generally recognized that for *fine grinding* a spherical medium is not essential or more efficient.

Another frequent objection to pebble grinding is the belief held by some operators that there is too much variation in the hardness of their particular ore to make it acceptable as a source of pebble media. Experience has also shown that this is not a serious problem at all. The variation in pebble load due to changes in the ore hardness is nothing like as great as most people would expect, and the method used for feeding the ore and controlling the the load in the mills is more than sufficient to take care of daily variations in ore hardness. This point

B. S. CROCKER, Member AIME, is Vice President and Director, Kilborn Engineering (1954) Ltd. TP 4801B. Manuscript, Oct. 6, 1958. AIME Rocky Mountain Minerals Conference, Salt Lake City, September 1958. AIME Trans., Vol. 214, 1959.

was well handled in a letter the author received from Rolland Merwin, mill superintendent of Neptune Mine, Nicaragua, with regard to wide variations in the hardness of the plant's mill feed. He reported no difficulty in maintaining smooth operation with normal supervision.[4]

Flint Pebbles: The use of hard pebbles for grinding ore is not a new metallurgical practice. Many operators in North America used either flint or Danish pebbles 30 or 40 years ago. These pebbles were either bought or mined from a local quarry and were usually fairly large in diameter, about the size of a man's fist. This resulted in somewhat inefficient operation, as the size of the pebble was frequently too large for the grinding job being done. At that time little thought was given to the importance of size of grinding media, which was governed to some extent by what was available on the market. The use of small grinding balls, and therefore small grinding pebbles, was actually introduced to the industry much later on. The contribution Lake Shore Mines made to autogenous grinding was to show a money-saving method of obtaining the pebbles (by screening them out of the jaw crusher discharge) with complete, quick, and easy control of pebble size. The grinding medium now represents a saving in the amount of ore that has to be crushed and at the same time represents an increase in the tons of ore milled per day. Under these circumstances, grinding with ore pebbles is more efficient and much more economical than grinding with steel balls. The Lake Shore test work and final plant operation clearly demonstrated that power used to grind the ore is exactly the same for ball milling as it is for grinding with the *correct* size of ore pebbles and under properly controlled conditions. The pebble mills are usually designed to be larger in diameter than the steel mills, and in this manner the same number of foot-pounds or the same amount of horsepower is developed.

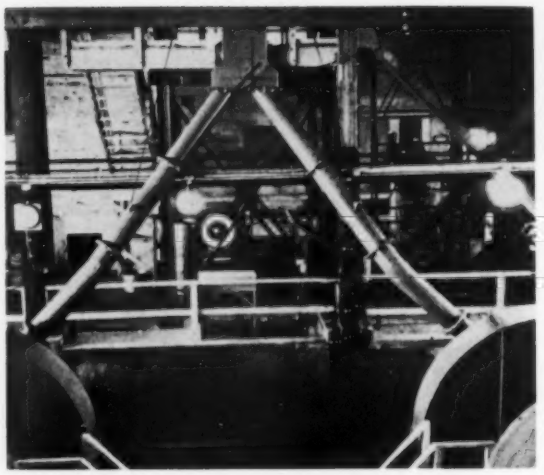


Fig. 2—Pebble feeding arrangement at Faraday Mines. Rock feed (pebbles) is drawn by a vibrating feeder, out of a storage bin shown at the top, weighed in a hopper and fed, at predetermined intervals, into the two pebble mills through the two rubber-lined pipes running to the combination feeders on the mills.

Table I. Diameter of Steel Balls and of Ore Having the Same Weight

Weight, Grams	Diameter of Steel Ball (7.8 Sp Gr)	Diameter of Ore Pebble (2.66 Sp Gr)
8.4	0.50	0.72
28.2	0.75	1.07
66.9	1.00	1.42
226	1.50	2.14
535	2.00	2.86
1807	3.00	4.27
4282	4.00	5.72
8364	5.00	7.17

Table II. Savings in Operating Costs at Lake Shore

	Savings Effected, $
Steel consumption 4.3 lb per ton @ $132.60	0.285
3.2 pct of the ore bypasses crusher and primary mills	0.016
Liner life saving	0.005
Primary agitation cuts through less iron in the grinding circuit, producing more oxygen in pebble mill discharge	0.013
Flotation tailing better, through stage grinding made possible by using several sizes of pebbles	0.028
Finer grind through more efficient small pebbles	0.030
Total	0.377

Table III. Savings in Operating Costs at Faraday

	Savings Effected, $
Steel consumption, 1.1 lb per ton	0.090
3.5 pct of the ore bypasses crusher and primary rod mills	0.015
Acid saved	0.025
Chlorate saved	0.030
Total	0.160

Pebble Size: The average pebble in the pebble load should be the *same weight* (not the same size) as the optimum size of steel balls. An empirical formula has been developed to relate the size of the screen used in sizing the rock feed to the size of pebble in the mill. At recent plants the rock feed has been screened in the crusher house through 2¾-in. or 3-in. square mesh screen and retained on 1½-in. square mesh screen. The −3+1½-in. screen combination gives a rock feed with a weighted mean size equivalent to a 2-in. pebble, after *rounding up* in the mill. The −2¾+1½-in. screen will give a weighted mean size equivalent to a 1½-in. pebble.[5] A 2-in. pebble is equivalent to a 1.4-in. steel ball and a 1½-in. pebble is equivalent to a 1.1-in steel ball.

As there are many factors other than screen openings which would affect the mean size of pebble in the mill, it is obvious that the proper procedure for any plant must be carefully studied to determine the best sizing combination to produce the correct pebble size for the sands being fed to any particular mill.

South African Practice: In South Africa, where autogenous grinding has been widely established for many years, cheap native labor is employed to hand-pick suitable pebbles—a situation that is not economical in many parts of the world. The natives pick the round pebbles and for convenience pick fairly large ones. The test run at Lake Shore Mines demonstrated that all of the screened ore could be used efficiently for fine grinding and not just the

round ones. Recent correspondence with Steve de Kok, who is metallurgical superintendent of Hartebeestfontein in the Union of South Africa, indicates that the South African mills are now using smaller pebbles and getting more efficient results.

"It is my view," writes de Kok, "that no ore is too soft to make it unsuitable for pebble milling." This has also been the author's opinion for a number of years, and it is interesting to find a similar view expressed by a metallurgist on another continent.

In South Africa the primary grinding is done in mills which are fed with large pebbles—about the size of a man's head—hand picked by natives and fed into the mill from a wheelbarrow. Up to the present time no completely satisfactory means of eliminating the wheelbarrow has been devised. The primary step, therefore, in all these grinding plants is to employ a small rod mill using 12 to 20 pct of total horsepower for wet grinding, to reduce the +¾ crusher product to about 6 mesh. These small rod mills are run in open circuit, and have proved very easy to operate.

Automatic Control: The new plants such as Bicroft, Faraday, and Dyno are almost completely automatic. When the pebble mill is started up the pebble feeding equipment is also started. The pebbles are automatically weighed in batch lots and fed into the mills at predetermined intervals. By watching the kilowatt demand meter used on these mills and varying the pebble feed rate, the operator can easily control the power being developed by the mill. This easily regulated power can also be used to vary the overall grind in the circuit. As a pebble load can be changed much more quickly than a steel load, there is a much greater degree of control available to the operators in these pebble grinding mills than in conventional ball mills. In South Africa Jack Williamson has recently proposed a control device in which the rate of feeding pebbles to the mill can be regulated to maintain a constant amount of power. This is a further improvement on the control of grinding in these circuits.

Flowsheet in Most Recent Plants: A brief discussion of the general arrangement of the plants in the Bancroft area will illustrate the grinding practice (Figs. 1 and 2). These plants are divided into two units, each handling about 600 tons of ore per day. A unit consists of a 6x8-ft primary rod mill operating at slow speed and drawing about 90 hp. The rod mill feed is −½-in. material and the rod mills are run in open circuit. The rod mill discharge passes to a classifier which is in closed circuit with a 9 x 11-ft grate discharge pebble mill, drawing from 240 to 260 hp, as required. The final grind over the classifier is 55 to 60 pct −200 mesh. These ores are of medium hardness, having a work index of 12. Rod consumption in the slow speed mills is ½ lb per ton and the two pebble mills consume a total of about 33 tons of ore per day. This 33 tons, representing about 3 pct of the rated tonnage of the plant, bypasses the fine crushing system and rod mill and is consumed in the pebble mills in grinding up the remainder of the ore. (Pebble consumption during the start-up period was considerably higher, averaging as much as 5 pct during the first six to eight weeks.) This represents a tonnage dividend over the rated capacity of the unit.

The ore pebbles are made by screening on scalping screens ahead of the secondary crusher. The pebbles pass through a 2¾-in. or 3-in. square mesh and are retained on a 1½-in. square mesh screen. Ore of this size is sent directly to the pebble bins as required. Usually enough of the pebble medium can be made in two or three hours to furnish a day's supply. The screened rock feed is stored in a special pebble bin placed alongside the fine ore bins and is then automatically weighed and fed into the pebble mills. The pebble storage bin need not be particularly large. As soon as new ore is crushed there is a ready supply of pebbles. In South Africa some plants keep only about one shift's supply of pebbles ahead of the mill. On this continent, with the modern trend of celebrating holidays on Mondays, fine ore bins are usually designed for three days' capacity and the pebble bins, accordingly, are usually designed to hold the same relative amount. This is in sharp contrast to plants using steel balls where three to six months' supply of the grinding medium is considered necessary to service the mills properly. This of necessity results in a large inventory tie-up of steel ball.

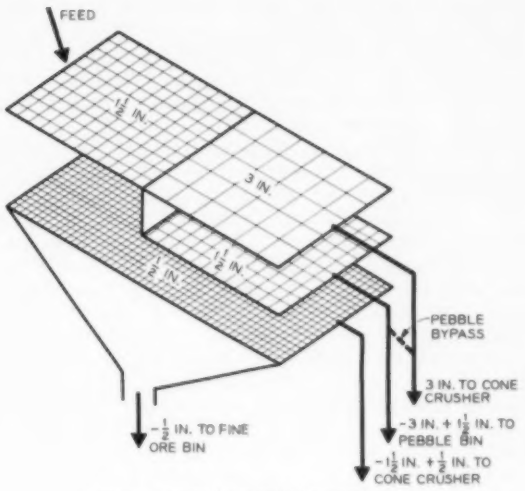


Fig. 3—Grinding pebble production.

Capital Cost of Autogenous Grinding Plants: Capital outlay for a modern pebble grinding plant of the type decribed above is only slightly higher than for an all-steel grinding plant, and further experience in design is continually lowering the cost. The chutes and the pebble feeding arrangements are extra for these plants. The pebble mills themselves are larger in diameter than steel mills of equal capacity, but they can be made of lighter materials, as the load is actually lighter. Also the steel mills must be supplied with an initial load of grinding balls. The steel mill, together with this initial ball load, costs about the same as the larger diameter pebble mill. When the cost of the customary four to six months' supply of grinding balls, together with storage bins and loading hoppers, is taken into account, the overall cost of the pebble grinding plant is not much greater than for the conventional steel plant.

On the conversion jobs, the capital cost of the conversion was realized out of the operating savings, in one or two years after the changeover was completed.

Operating Cost Savings: In 1957 the pebble grinding plants showed savings of 10¢ to 38¢ in operating costs per ton of ore milled. The greatest

savings were naturally made with ores which were ground the finest, and on which the greatest percentage of fine grinding equipment was converted to pebble milling. The savings shown in Tables II and III were taken from the Lake Shore Mines and the Faraday reports.[2, 6]

Pebble Grinding on Sulfide Ores: Of the plants listed above, all except the North Rankin Nickel Mines were grinding essentially siliceous ores. On these ores the specific gravity of the grinding medium is approximately 2.7. In autogenous grinding with sulfide ores allowances must be made for the heavier specific gravity of the ore. Experience has shown, however, that the more siliceous part of the ore is usually harder and therefore tends to build up in the pebble load, so that the final specific gravity of the grinding medium is often lower than that of the ore itself. This must be carefully evaluated in the test work, as the heavier the grinding medium the greater the capacity of a given mill. The chemical action within the grinding mill is also different from that experienced within the grinding mills using steel media. The action is usually less reducing. This is a very definite advantage in cyanide plants or uranium leach plants. It is not a disadvantage in flotation plants but may call for a slight change in the conditioning technique prior to flotation. It had no adverse effect on the nickel-copper float at North Rankin Nickel Mines. At Tennessee Copper, during pilot plant work on pebble grinding, this copper zinc ore was floated successfully after slight modifications of the usual practice. It is imperative, therefore, to run laboratory test work on flotation ores, using the ore pebbles in the laboratory grinding mills. This can be accomplished quite easily in any laboratory equipped to do flotation testing and it should be carried out during the preliminary test work so that the prospective client is free to choose any method of grinding with the assurance that the overall metallurgy will not be prejudiced.

Flexibility of Pebble Plants: Because these pebble plants are more flexible than the plants equipped with steel grinding balls, their efficiency is greater. For mills that are filled with steel balls, six to eight weeks are needed to change the ball size in the mill completely, to say nothing of the six months' supply of balls usually on hand, which would have to be used up before a new size of grinding ball could be introduced into the mill. Also, if the operator wished to change to a smaller size of grinding ball he would usually find that he had to pay a greater price for the smaller ball. These factors discourage most mill men from even attempting to change the grinding medium to suit changes in tonnage or changes in the plant's fineness of grind. In the pebble grinding layout, however, the operator can increase or decrease the size of grinding medium to suit conditions simply by changing one screen in the crusher house, and the pebble load is completely changed in two to four days. Here is a degree of control that opens up new fields in grinding efficiency.

Pebble Consumption: Table IV lists the pebble consumption, expressed as pounds per kilowatt-hour for a number of operating plants. Unlike steel consumption in grinding mills, the larger the pebble the greater the consumption. This is demonstrated in the Lake Shore results and in the results on the Rand. Generally the ores with a high Bond *work index* show a smaller consumption per kilowatt-hour than softer ores, as would be expected. The percent symbol under Pebble Consumption (column J) in Table IV refers to the percentage of total feed to the grinding circuit that is represented by the pebble feed.

High-Speed Mill Operation: Recently R. T. Hukki[9] called attention to the benefits to be derived from running autogenous fine grinding mills at supercritical speeds. Some interesting results have been obtained in Finland along these lines. Excessive steel consumption was one of the chief objections to running ball mills at high speeds. However, in autogenous grinding extra pebble consumption is an advantage rather than a disadvantage, and higher speeds are much more attractive. This is an interesting new field of operation which should be studied thoroughly.

REFERENCES

[1] B. S. Crocker: Screened Ore Used for Fine Grinding at Lake Shore Mines. *AIME Trans.*, 1952, vol. 193, pp. 449-508.

[2] B. S. Crocker: Fine Grinding with Screened Ore at Lake Shore Mines. *Trans., Canadian Institute of Mining and Metallurgy Bulletin*, 1954, vol. 57, pp. 115-128.

[3] R. Tanner and T. Heikkinen: Crushing and Grinding at Outokumpu. International Mineral Dressing Congress 1:4. Stockholm, 1957.

[4] B. S. Crocker: Pebble Grinding Gains Slowly in Canada. *Northern Miner* (Annual Review number), Nov. 28, 1957, p. 65.

[5] R. W. Merwin (Neptune Gold Mining Co., Bonanzo, Nicaragua): Private correspondence.

[6] R. J. Roach: Pebble Milling at Faraday Uranium Mines. 5817 AB.

[7] J. D. Bryce and J. M. Thompson: The Bicroft Uranium Mines Operation. 5820 Pl.

[8] *Hardinge Highlights*, October 1957, no. 45.

[9] R. T. Hukki: Fine Grinding at Supercritical Speeds. *AIME Trans.*, 1958, vol. 211, pp. 581-589.

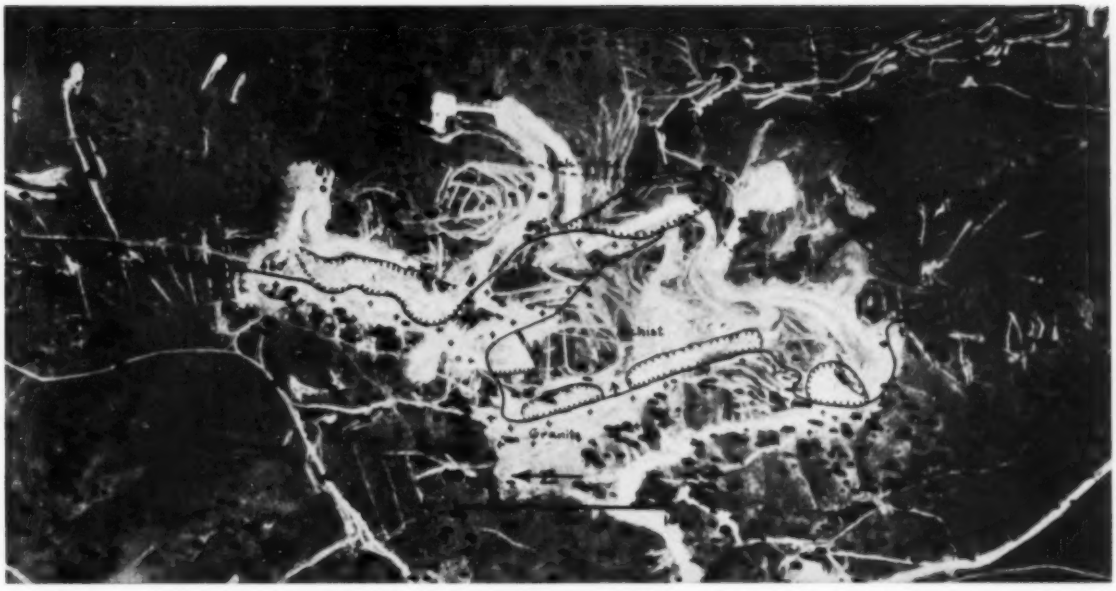
Discussion of this article sent (2 copies) to AIME before June 30, 1959, will be published in MINING ENGINEERING.

Table IV. Pebble Consumption

	A	B	C	D	E	F	H	I	J	K	L
			Pebble Mill						Pebble Consumption		
Mine	Ore, Sp Gr	Ore Hardness (Wi.)	Size	Power, Kw	Tph	Pebbles, Lb per Hr	Theor. Pebble Size, In.	Kw-Hr per Ton	Pct	Lb per Ton	Lb per Kw-Hr
Lake Shore, Ontario	2.7	16	6 ft 8 in. x 16 ft	130	5.2	221	1.25	24.8	2.1	42	1.7
			6 ft 8 in. x 16 ft	130	5.2	329	1.75	24.8	3.2	63	2.5
Bicroft, Ontario	2.7	13	9x11 ft	210	23	1265	1.75+	9.1	2.75	55	6.0
Start-up									5.0	100	11.0
Faraday, Ontario	2.7	12	9x11 ft	194	25	1750	2	7.8	3.5	70	9.0
Start-up									7.0	140	18.0
Rand, South Africa	2.7	?	8x16 ft	218	44	2340	5.75	5.0	2.65	53	10.6
	2.7	?	8x16 ft	221	44	2000	3.4	5.0	2.3	46	9.2
	2.7	?	8x16 ft	179	44	918	1.8	4.1	1.05	21	5.1
Merriespruit, South Africa	2.7	?	8x16 ft	210	13.0	2660	2.3	16.1	10.0	200	12.4
Neptune, Nicaragua	2.7	?	5x10 ft 6x10 ft 7x15 ft	212	30	918	2.3	7.1	1.5	31	4.4
Renabie, Ontario	2.7	18	9x11 ft	194	11.2	945	1.9	17.3	4.2	84	4.8
Outokumpu, Finland	3.6	?	9x12 ft	150	25	2250	2	6.0	4.5	90	7.7

MIDNITE MINE
GEOLOGY AND DEVELOPMENT

by R. F. SHELDON



Aerial photo of southern section shows locally irregular granite-schist contact and six of the known orebodies.

Largest uranium deposit in the Northwest is Dawn Mining Co.'s Midnite mine on the Spokane Indian Reservation. The orebodies lie along the contact of granite and metamorphosed sedimentary rock and are controlled by faults and shear zones near the granite contact. In the oxidized zone the deposits consist mainly of the secondary uranium mineral meta-autunite; sooty uraninite and primary uranium minerals are known to occur at greater depths.

Elevations in the mine area range from 2500 to 3500 ft. The rolling hills and low, rounded mountains are covered with grass and evergreen trees.

R. F. SHELDON is a Geological Engineer with Newmont Exploration Ltd., Spokane, Wash. TP 4796I. Manuscript, May 26, 1958. Pacific Northwest Regional Conference, April 1958. AIME Trans., Vol. 214, 1959.

HISTORY AND DEVELOPMENT

Original showings were discovered with a geiger counter in the spring of 1954 by prospectors Jim and John LeBret. High radioactivity in several schist outcrops was found due to scaly coatings of a greenish-yellow, fluorescent mineral, later identified as meta-autunite. Prior to this time autunite was not known to occur in the state of Washington, and no significant uranium deposits had been found in the Pacific Northwest.

Outcrops in the area were few, and most of the ground was mantled with 2 to 10 ft of overburden, but three other radioactive zones were discovered by prospecting the ridge southward along the strike of the schist near its contact with granite for three quarters of a mile. Midnite Mines Inc. was formed

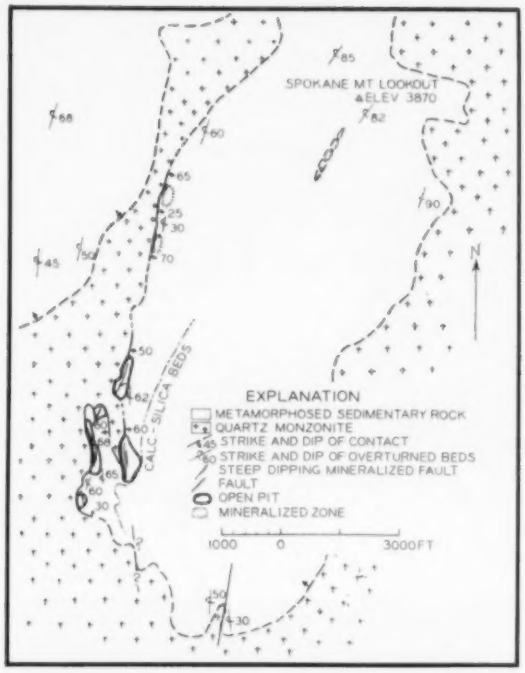


Fig. 1—Geological map shows location of orebodies.

to investigate these showings, which were trenched and opened up by bulldozer. It was soon apparent that ore occurred in economically mineable quantities, and late in 1954 a contract was obtained to ship 2400 tons to the AEC. To gain further structural and mineralogical information about this new deposit the AEC drilled 13 short diamond drill holes on the property, with generally encouraging results.

Dawn Mining Co., organized in the spring of 1955, is jointly owned by Newmont Mining Corp., which controls 51 pct, and Midnite Mines Inc. of Washington. During the summer of 1955 this newly organized company carried out an intensive development program, including 25,000 ft of wagon drilling, 550 ft of underground work, geological and radiometric mapping, bulldozer trenching, stripping of selected areas, and limited mining in three of the orebodies. Wagon drill holes as deep as 160 ft on a 50-ft grid pattern explored the granite-schist contact for a distance of a mile and a half. An adit was driven into one of the orebodies to check drilling results and gain a better idea of the physical nature of the ore and rock, while two other ore zones were developed by open pit mining. Bulk samples of the mined ore were taken for metallurgical tests.

This program indicated enough ore in six orebodies to justify building a mill, and a milling contract was negotiated with the AEC. The 440-tpd processing plant, approved in mid-1956, was completed by Western Knapp Eng. Co. in August 1957.

Open pits were designed from the drilling results, and stripping and mining, under contract to Isbell Construction Co., began in the fall of 1956. Equipment used in mining the 20-ft benches includes a Winter-Weiss rotary drill, a Gardner-Denver wagon drill, a 1-cu yd shovel for use in ore, a 2½-cu yd shovel for waste, and six 22-ton capacity Euclid trucks. As rock is loaded at the pit face, it is graded by a sampler using a shielded Babbel counter, which is calibrated in a high radiometric background to simulate pit conditions. This grade control has been most effective, usually within 0.02 pct U_3O_8 of chemical assays, as the ore is generally in balance radiometrically and chemically. About three tons of waste are removed to recover each ton of ore.

The mining and hauling, which depend on weather and road conditions, are carried on during May through January. In 1957, 592,000 tons of waste were stripped, 164,000 tons of ore mined and hauled to the mill, and 151,000 tons of low grade ore placed on the protore stockpile.

REGIONAL GEOLOGY

Midnite mine lies within the Turtle Lake Quadrangle currently being mapped by the USGS.[1] A series of Pre-Cambrian argillites, phyllites, quartzites, slates, and dolomites—separated by an erosional unconformity from Paleozoic quartzites, argillites, and dolomitic marble—form irregular, northerly-trending roof pendants surrounded by the Loon Lake granitic batholith, which consists of granodiorite, quartz monzonite, and alaskite believed to be of Cretaceous age.[1,2] The Pre-Cambrian and Paleozoic rocks are folded and overturned to the west into a north to northeast-trending series, the older rocks lying to the east. Remnants of Tertiary lava flows remain in some areas, and the terrain is modified by glacial action and the resulting deposition of silt and moraine. No individual faults of major magnitude have been recognized, though the area as a whole is laced by a series of northward-trending fractures.

The regional sequence of geologic events has been interpreted as follows:[2]

1) Deposition of a thick series of late Pre-Cambrian sediments believed to be part of the Belt group. The basal Togo formation alone appears to be more than 20,000 ft thick.

2) A long period of Pre-Cambrian erosion, but little deformation. The unconformity between the Pre-Cambrian and Paleozoic rocks represents about 8600 ft of erosion.

3) Deposition of Paleozoic sediments under relatively stable conditions.

4) Folding and faulting in the Mesozoic era. The source of pressure was from the east, resulting in northerly-striking anticlinal axes and overturning of the beds to the west.

5) The relatively quiescent batholithic intrusion of Cretaceous (?) granitic rocks.

6) Post-intrusive erosion of the order of 5000 ft.

7) Deposition of Tertiary lava flows that covered local areas.

8) Pleistocene glaciation.

9) Retreat of the glaciers, leaving moraines and silt-filled basins.

LOCAL GEOLOGY

Rock Types: The uranium deposits at the Midnite mine are found in a roof pendant of Pre-Cambrian Togo formation along its northerly-trending contact with the Loon Lake granitic batholith.

In the mining area the Togo formation consists of buff to dark gray, thin-bedded, silicious, argillite schist that has been locally altered by thermal metamorphism to phyllite, hornfels, and knotted schist for as much as 200 ft from the granite. Microscopic observations of thin sections show the development of the metamorphic minerals tremolite, andalusite, and wollastonite. The schistosity is parallel to the

bedding except for local deviations. Small seams and lenses of hematite have been noted in the argillite, and iron and manganese oxide stain is common. A few hundred feet east of the contact the lithology of the Togo changes to beds of buff-gray, impure, silicious, dolomitic limestone, locally called *calc-silica*, that contain diopside, epidote, feldspar, and garnet. Eastward these beds are progressively thicker and more limey.

The Loon Lake granite on the property is represented by a coarse-grained quartz monzonite with pegmatite facies. The feldspars are commonly slightly altered, rendering the rock much softer than normal. The granite is more easily weathered and eroded than the sedimentary rocks; hence the valleys are generally underlain by granite, whereas the more resistant metamorphosed sedimentary rocks form the ridges.

Structure: The Midnite mines property covers the western side of a south-pointing lobe of metamorphosed sedimentary rocks two miles long and three quarters of a mile wide, flanked and underlain by the granitic batholith (Fig. 1). In cross section the lobe is roughly saucer-shaped, with steeply dipping sides that rapidly flatten off to a rolling base (Fig. 2). Diamond drilling has shown depths of metamorphosed sedimentary rocks down to 500 ft before penetrating granite.

The drag-folded metasediments are the remaining portion of the western flank of a northerly-trending, overturned anticline. Marker beds within the more highly altered and broken contact area are lacking. The *calc-silica* horizon, however, is distinct, and exposures and drillholes along these beds indicate drag folds that plunge flatly north. In the mine area the general dip of the granite contact is to the east at angles from 30° to 70° parallel to the bedding. In detail, the contact is irregular, with apophyses of granite as noses, dikes, and sills intruding the schist along natural weaknesses formed by bedding planes, drag folds, and faults.

Faults: Steeply dipping faults are prevalent, especially in the metamorphosed sedimentary rocks, although no major displacements have been noted. Stress relief appears to have favored a great number of small displacements. Both pre-granite and post-granite faulting have occurred. In the mining area one fault shows a dip-slip of 15 ft on a granite-schist contact; all others observed to date show lesser movements. Most of the fracturing and shearing in the metasediments is due to pre-granite folding, whereas the faults within the granite are probably the result of differential cooling stresses. The stronger faults trend northerly and represent ruptures along fold axes. Bleaching and softening of the wall rocks is common to most of the faults and shear zones. A few late faults originating in the granite have provided the channelways for the hydrothermal uranium-bearing solutions. The sides of the mineralized faults in places show up to 15 ft of wall rock bleaching, accompanied by light pyritization and silicification.

Size and Shape of Deposits: Eight more or less separate orebodies are now known to occur on the property, strung out intermittently for one mile along the granite contact (Fig. 1). Two of these bodies had no surface expression and outcrops of the others gave generally scant evidence of their potential at depth.

Individual orebodies may be as much as 700 ft long, varying irregularly from a few feet to 200 ft wide. A typical generalized cross section of an orebody is shown in Fig. 2. In detail, however, the ore can be very irregular in the oxidized zone, where the shape is influenced by bedding and schistosity, faults, shear zones, slips, dikes, sills, and generally any factors affecting permeability of the rock. As the base of the oxidized zone is reached the ore gradually becomes more restricted to the environs of the mineralized faults. There is no sharp cutoff to the zone of oxidation, as it is dependent upon perched water tables in the schist.

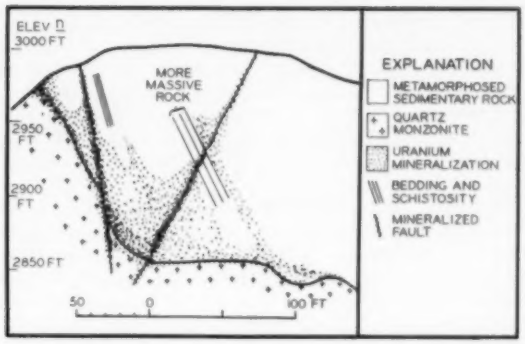


Fig. 2—Typical generalized cross section of an orebody at Midnite mine illustrates primary control of uranium mineralization along faults and the effect of rock permeability upon localization of secondary mineralization.

None of the orebodies to date have been mined to a depth completely devoid of oxidation effects, but drilling indicates that once the mineralized faults enter the granite the ore is restricted in width to only a few feet.

Mineralization of Deposits: The following uranium minerals have been identified from the Midnite mine:

Identification	Primary Minerals	Secondary Minerals	
Positive	Uraninite Coffinite	*Meta-autunite Zippeite Sklodowskite Sooty uraninite	Uranophane Phosphuranylite Liebigite
Tentative	Pitchblende	Torbernite Delvauxite	Gummite

* On drying or slight heating autunite passes reversibly to meta-autunite.

Most of the secondary uranium minerals are phosphates and silicates. The only metallic gangue mineral found in appreciable amounts is very fine-grained pyrite, which rarely exceeds 2 pct. Traces of molybdenite have been seen in drill cuttings and cores. A few erratic quartz veinlets a few inches to a foot wide occur but are barren of mineralization other than pyrite.

Meta-autunite, with lesser amounts of uranophane and sooty uraninite, has been the chief ore mineral mined to date. Three of the pits are now mined down to the semi-oxidized zone, where sooty uraninite is becoming predominant. The sooty uraninite is considered to represent the oxidation, essentially in place, of the primary uranium minerals, with only local movement and redeposition. It is expected that as mining progresses below the oxidized zone the primary mineralization found in drill cores and cuttings will appear.

There have been no age determinations received on the uranium. However, it is assumed that the

mineralization is a product of the granite intrusive and probably of Cretaceous age.

Ore Controls: Study of ore control at the Midnite mine involves factors affecting both primary emplacement of uranium and secondary redistribution of the mineralization by meteoric waters. A brief history of the formation of the uranium orebodies may be interpreted as follows:

Intrusion and cooling of the granitic batholith resulted in formation of fault fissures in the relatively brittle, thermally metamorphosed sedimentary rocks along the contact area and permitted the ascension of primary uranium solutions. Several thousand feet of erosion, accompanied by oxidation and ground water leaching of the primary uranium, permitted residual accumulation of the easily reprecipitated uranium as secondary mineral coatings in the fractured schist and, to a lesser extent, in the more impermeable granite. The sheeted nature of the schist, together with gougey transverse slips, caused perched water tables and a directional movement of ground waters tending to concentrate the redeposition of uranium in certain areas. The oxidized zone ranges from 40 ft to more than 150 ft below surface, depending on topography and the water table.

In the search for ore and for localization of ore in the area, the following features should be considered:

1) All the orebodies found to date lie in metasediments along the granite contact—preferably a steeply dipping contact. Locally, however, adjacent to ore zones in the schist, secondary uranium solutions have percolated into fractured zones in the granite or formed surface coatings around the kaolinized feldspar crystals.

2) The orebodies favor irregularities in the granite-schist such as noses, embayments, and changes of strike and dip.

3) The primary channelways of mineralization are northerly-trending, steep-dipping faults close to and roughly paralleling the granite contact. In the three orebodies that have been mined nearly down to the oxidized zone, one or two gougey, mineralized fault zones in each case contain sooty uraninite and appear to be the loci of the primary uranium solutions. Owing to leaching, the mineralized faults are often indistinguishable from unmineralized faults in the upper zone of oxidation. The mineralized faults seem to be those that were able to maintain themselves for an appreciable distance at some angle to the bedding and schistosity of the metamorphosed sedimentary rocks and remain open, thus allowing transport of ascending mineralizing solutions. None of these faults have been traced for more than a few hundred feet, however, as they tend to lose their identity either by aligning themselves with the bedding and schistosity or by gradually dying out in earlier formed shear zones.

4) Physical characteristics of the rocks have been important in ore localization. The brittleness and thin-bedded nature of the metasediments in the contact area have played a large part in both primary and secondary deposition of the ore.

The mineralized faults were able to persist in the competent rocks but were not able to maintain themselves in softer rock types. It is therefore believed that the dolomitic calc-silica beds lying next to the phyllites and argillite schists tended to flow or failed by weak shears under the confining rock pressures during the period of primary uranium mineralization, and any fissures that formed healed themselves. Ore does occur in the calc-silica beds, but only as a continuation of ore in the adjoining schist. It seems likely, however, that the calc-silica beds were important in buttressing the argillite schist, making it more competent and susceptible to fracturing.

The thin bedding in the metasediments has favored brecciation and permeability, resulting in wider zones of both primary and secondary mineralization. The concentration of secondary mineralization, to ore grade especially, requires the thin coating of a large number of rock faces. The more massive, thicker-bedded sections of argillite schist are therefore not generally favorable.

5) The directional permeability of the schist and the relative impermeability of the main granite body; granite dikes and sills; and numerous gougey faults, shears, and slips have resulted in the transport of the leached uranium by meteoric water to structural basins and traps, where redeposition has taken place and deposits of secondary ore have been formed. The main granite contact has been especially effective in containing the secondary solutions. The secondary ore zones are very erratic in places and are dependent upon the attitude and degree of permeability of the numerous slips, faults, and shear zones.

6) All the orebodies discovered to date occur either along the crests of ridges or on steeply sloping sidehills. There are probably at least two reasons for this: 1) The harder, easily fractured rocks favorable for uranium deposition are also the most resistant to weathering. 2) The effective concentration of uranium as secondary deposits of ore requires a seasonally fluctuating water table allowing the percolation and redeposition of uranium in structural traps.

Midnite's uranium orebodies, which are localized along the contact between granitic intrusive rocks and metamorphosed sedimentary rocks, constitute the largest known deposit of this type in America. It is anomalous that the site of the initial discoveries still represents the only appreciable deposit of its kind found in the surrounding region, despite extensive prospecting of the contact zone for many miles. There is a similar deposit now under development near Austin, Nev., and the Rum Jungle deposit in Australia[4] has been described as having several geological features common to the Midnite mine.

The writer wishes to thank members of the AEC and the USGS and the staff and management of Dawn Mining Co. and Midnite Mines for help in gathering some of the information presented in this article.

REFERENCES

[1] G. E. Becraft and P. L. Weis: Preliminary Geologic Map of the Turtle Lake Quadrangle, Lincoln and Stevens Counties, Washington. *USGS Survey Map MF135*, 1957.

[2] I. Campbell and J. S. Loofbourow, Jr.: *Preliminary Geologic Map and Section of the Magnesite Belt*, Stevens County, Washington, 1946.

[3] P. L. Weis: Personal communication.

[4] N. H. Fisher and C. J. Sullivan: Uranium Exploration by the Bureau of Mineral Resources, Geology and Geophysics in the Rum Jungle Province, Northern Territory, Australia. *Economic Geology*, 1954, vol. 49, no. 8, p. 828.

Discussion of this article sent (2 copies) to AIME before June 30, 1959, will be published in MINING ENGINEERING.

APPLICATION OF ELECTRON DIFFRACTION AND ELECTRON MICROSCOPY TO MINERAL ENGINEERING

by J. E. LAWVER and G. L. SAMSEL

The success of many mineral dressing processes, including froth flotation and electrical concentration, depends largely on knowledge of physical and chemical structures of the mineral surfaces involved. As a general rule solids have surface layers, usually invisible by optical tests, that differ from the substratum. To the mineral engineer, therefore, a knowledge of the surface structures of minerals is of paramount importance.

During the past decade one of the most powerful tools in the study of froth flotation mechanisms has been the use of radioactive tracers, but this technique usually cannot give definite information regarding the chemical changes that may or may not have occurred at the surface.

The electron microscope and electron diffraction camera can be particularly useful instruments in surface studies. An electron microscope permits much closer examination of surfaces than can be obtained with a petrographic microscope. In certain cases, it is possible to identify trace quantities formed by chemical reaction between flotation agents and mineral surfaces by the use of a single-crystal, reflection electron diffraction camera. This article describes several instances in which these instruments have been valuable guides in mineral dressing research at International Minerals & Chemical Corp.

One of the first applications of these techniques employed by International Minerals was in conjunction with the study of electrical concentration of potash ore. The first reasonably successful separation of potash ore was made by subjecting a sample of the ore to a methanol wash. Subsequent tests using tagged $_6C^{14}$ methanol showed that only a minute quantity of radioactivity was detectable after the methanol-washed sample had been dried and heated to about 300°F. It was concluded that although some methanol had been held to the surface by adsorption, this could not account for the improved electrification because there was no evidence of methanol selectivity with respect to NaCl or KCl. Consequently there must have been some other change in the surface.

Carbon replicas* of the mineral grains were made before and after the methanol wash. The replicas were separated from the minerals by dissolving in water. This extraction replica technique is particularly attractive because the specimen can first be used with the electron microscope to observe the general structure of the surface and can be re-used as a specimen for electron-diffraction studies to identify any solvent insoluble material present on the mineral surface.* Fig. 1 shows the general

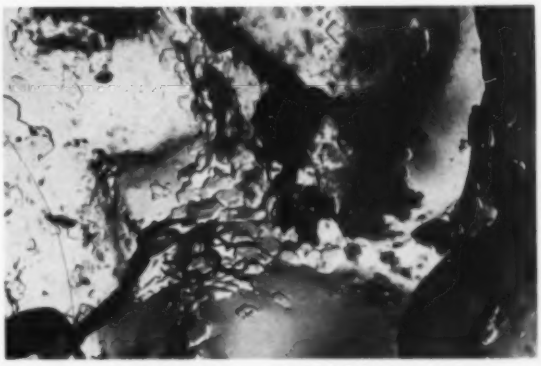


Fig. 1—Raw sylvite. X9800.

Fig. 2—Methanol-washed sylvite. X17,800.

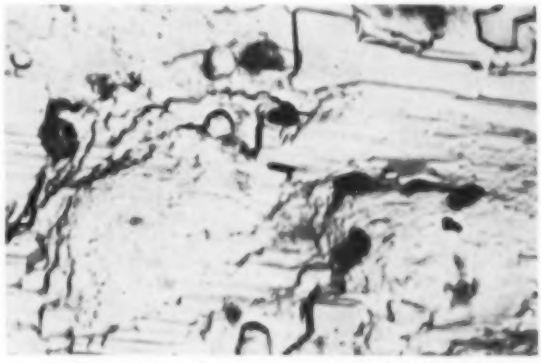


Fig. 3—Sylvite heated to about 510°C. X7300.

* For details of preparing surface replicas see Refs. 1 and 2.

* Many electron microscopes are equipped with a selected area diffraction attachment so that the experimenter can often identify trace materials present in a selected area of the replica.

J. E. LAWVER, Member AIME, is Research Specialist and G. L. SAMSEL is Senior Research Chemist, Mineral Processing Dept., International Minerals & Chemical Corp., Mulberry, Fla. TP 4803B. Manuscript, June 9, 1958. AIME Trans., Vol. 214, 1959.

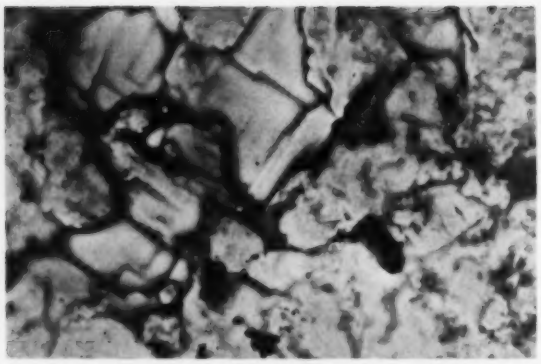


Fig. 4—Halite heated to about 510°C. X7300.

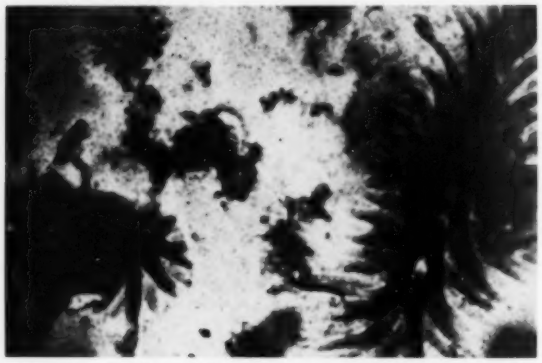


Fig. 5—Caprylic acid spreading over slime-coated sylvite. White area is true mineral surface. X9800.

appearance of the surface (as observed with an electron microscope at 11,000 X) before the methanol wash. The black areas are water-insoluble complex slimes identified by the electron diffraction pattern.

Fig. 2 is an electron micrograph of the methanol-washed sample. Note that the surface has been etched and that most of the water-insoluble slime has been removed. Although the surface appeared clean, electrostatic tests on the methanol-washed ore gave results which, on analysis, indicated that other factors were operating. Further examination of single particles using reflection-diffraction techniques indicated that many particles were covered with a film of both NaCl and KCl, probably due to the slight but finite solubility of both salts in methanol. The presence of this film tended to lower the selectivity of electrification of the two minerals. At a later date it was found that satisfactory electrical concentration of this ore (without solvent treatment) could also be made by heat treatment.[3] Although the effect of heat treatment is complex and cannot be completely explained by electron micrographs, the change in surface structure due to heating is intriguing. Fig. 3 is an electron micrograph of a sylvite grain that has been heated to a temperature between 480°C and 540°C. Fig. 4 is a corresponding micrograph for a halite grain. (Note that new surfaces have formed.) These fresh slime-free surfaces apparently are the reason that potash ore can be electrically concentrated after heat treatment.

Another application of these techniques employed by International Minerals has been in the study of interactions between surface-active agents and mineral surfaces. The study of surface-active agents by electron diffraction and electron microscopy is limited to substances that do not completely volatilize under high vacuum. Fortunately, many surface-active agents of interest to the metallurgist do not volatilize; hence the technique is very useful in this area of research. For example, Fig. 5 is a micrograph showing the spreading action of caprylic acid over a slime-coated section of potash ore. The slime is gray, whereas the caprylic acid is black, and the white area is the true mineral surface. Note the selectivity of the spreading action of the surface-active agent. Reagent covering of the clay surface apparently improves the amenability of the particles to beneficiation.

Although the micrographs accompanying this article give considerable insight as to surface properties of minerals, it is important to note that it is not posssible to deduce directly the exact surface state in a flotation pulp by observing electron micrographs obtained using a dry system under vacuum. These few examples have shown, however, the usefulness of the electron diffraction and electron microscope as an aid to better understanding of surface phenomena.

REFERENCES

[1] C. E. Hall: *Introduction to Electron Microscopy*. McGraw-Hill Book Co., New York, 1953.
[2] R. B. Fischer: *Applied Electron Microscopy*. Indiana University Press, 1954.
[3] J. E. Lawver: U. S. Patent 2,805,768.

Discussion of this article sent (2 copies) to AIME before June 30, 1959, will be published in MINING ENGINEERING.

Discussion

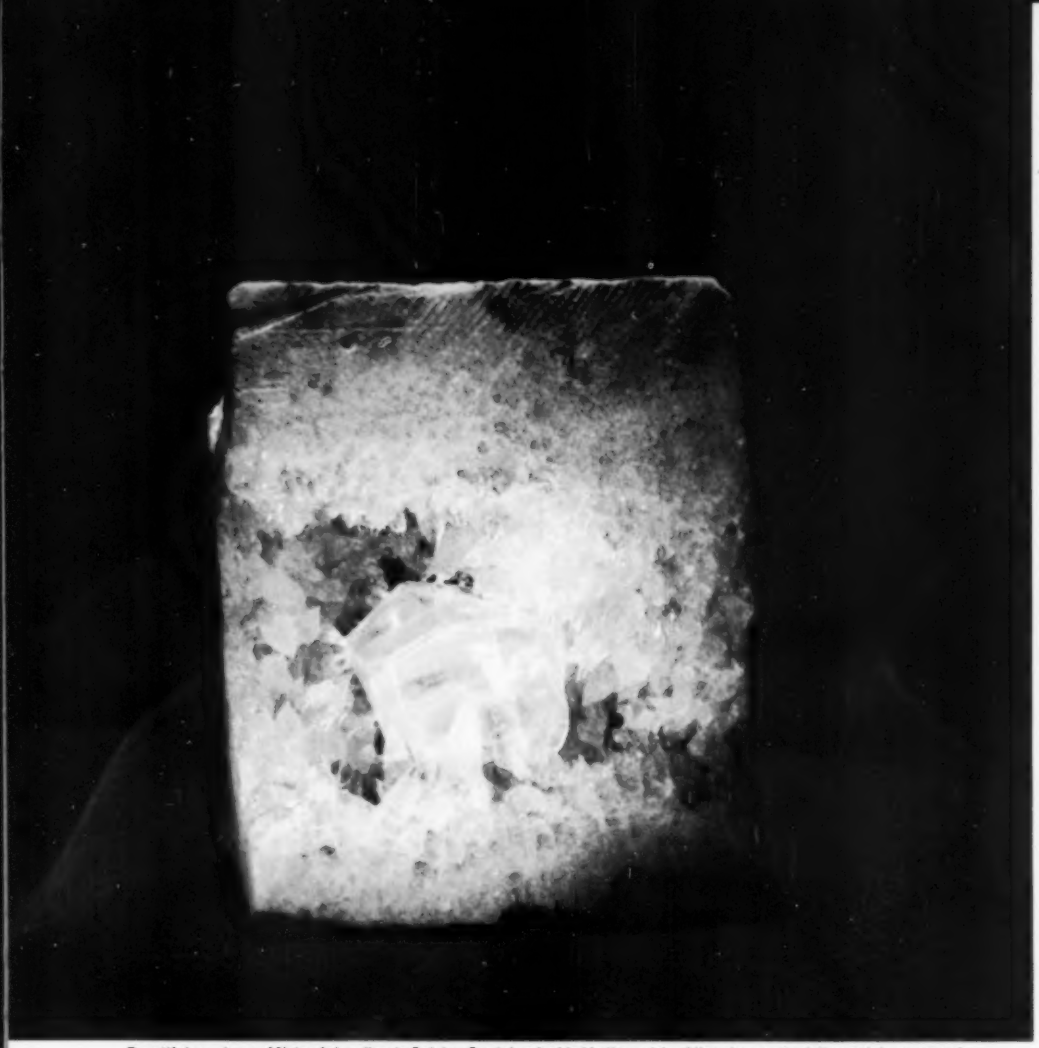
GRINDING BALL SIZE SELECTION

by **F. C. BOND**

(MINING ENGINEERING, page 592, May 1958, AIME Trans., Vol. 211)

B. H. Bergstrom *(Allis-Chalmers Mfg. Co., Milwaukee)*—In reading this article, it was difficult to follow through the example given as a starting point in the derivation of the theoretical equation which relates ball size to feed size. A discussion with F. C. Bond led to the following clarification:

Bond postulates that "the breaking force exerted by a ball varies . . . as the cube of its diameter . . ." and that the force in pounds per square inch required to break a particle varies . . . as its diameter squared." He concludes: "It follows that when a 1-in. ball breaks a 1-mm particle, a 2-in. ball will break a 4-mm particle, and a 3-in. ball a 9-mm particle." The above example can be true only for a different set of assumptions. Since the first assumption is apparently true, it is the second that must be revised. The second assumption should read that the breaking force required to break a particle varies as its diameter to the 3/2 power. This relationship was derived in the next paragraph of the article.



Beautiful specimen of Nature's handiwork: Sulphur Crystal embedded in the matrix of limestone and calcite crystals recovered from a drill core taken hundreds of feet underground while exploring a Sulphur deposit. (Ektachrome by Keturah Blakely)

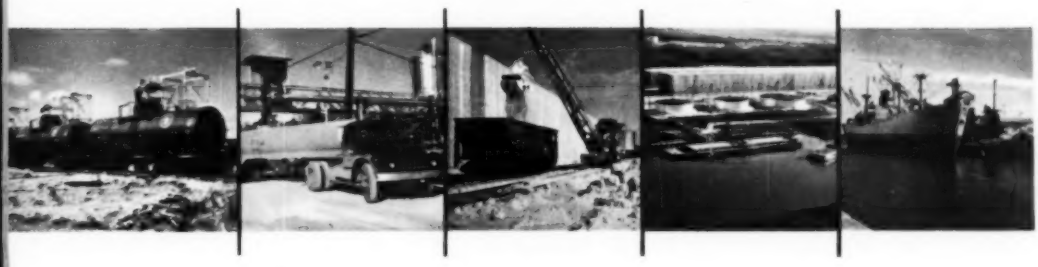
from the company that is Staffed, Equipped and Stockpiled for Service

Solid Sulphur by Rail, Barge, or Ship

Molten Sulphur by Rail, Truck or Barge, from Mines or Strategically Located Terminals

Technical Service on problems involving the Use and Handling of Sulphur

SULPHUR



from left to right:
Loading Tank Cars with Molten Sulphur
Loading Tank Trucks with Molten Sulphur
Loading Gondolas with Solid Sulphur
Loading Barges with Molten Sulphur
Loading Freighters with Solid Sulphur

TEXAS GULF SULPHUR CO.
75 East 45th Street, New York 17, N. Y.
811 Rusk Avenue, Houston 2, Texas
Sulphur Producing Units: Newgulf, Texas • Spindletop, Texas • Moss Bluff, Texas • Fannett, Texas • Worland, Wyoming

NOTICE---SME PREPRINT AVAILABILITY

The following list of papers (from the 1959 San Francisco Annual Meeting) will be available until Jan. 1, 1960. Coupons received with the 1959 dues bills and those distributed at the 1959 Annual Meeting will also expire on this date. Purchased coupon books will be honored on any future date. A new listing of available papers will appear in a forthcoming issue. It will include additional papers presented at the 1959 Annual Meeting (San Francisco) and at other SME meetings throughout the year. Preprints may be obtained (upon presentation of properly filled out coupon) from SME Headquarters, 29 W. 39th St., New York 18, N. Y. Coupon books may be obtained from SME for $5 a book (10 coupons) for members or $10 a book for nonmembers. Each coupon entitles the purchaser to one preprint.

59H1—Water Law and Its Significance to the Mining Industry by Wells A. Hutchins.
59H2—Relation of Land Subsidence to Groundwater Withdrawals in the Upper Gulf Coast Region, Texas by Leonard A. Wood and A. G. Winslow.
59F3—Hydraulic Mining of Gilsonite and Its Application to Coal Mining by J. H. Baker.
59H4—Recovery of Phosphates by In Situ Fluid Mining by Sylvain J. Pirson.
59F5—Coal Cleaning Plant Design for Minimum Operating Labor by Wm. M. Bertholf and John D. Price.
59F6—Coke Combustibility: A Neglected Characteristic by J. D. Price.
59B7—Union Carbide's Uranium Operation at Maybell, Colorado by K. W. Lentz and F. T. Temple.
59H8—A Rapid Method for Estimating Alumina in Feldspathic Sands by Hugh H. Bein.
59H9—Water Laws as Related to Dredging in Idaho by Robert A. Lothrop, Richard B. Porter, and Robert P. Porter.
58B10—Separation and Washing of Alumina Process Residue by Morton Handelman.
59B11—Feed Preparation and Froth Modification for Fatty Acid Flotation by Carl C. Martin and Burt C. Mariacher.
59B12—Design Requirements for Tailing Disposal in the Southwest by E. Vern Given.
59B13—Semi-Dome Shaped Buildings for Bulk Storage by Edward E. Ives and William L. Payne.
59H14—Flow of Limestone and Clay Slurries in Pipelines by Ross W. Smith.
59H15—CO_2 Gas as a Cement Slurry Thinner by Duncan Williams and H. Potter.
59H16—Potash in Saskatchewan by Marion A. Goudie.
59B17—Pebble Milling Practice in the Reduction Works of the Gold Mines of Union Corp., Ltd. by O. A. E. Jackson.
59L18—The Bonanza Project, Bear Creek Mining Co. by Douglas R. Cook.
59J19—Preregistration Counseling for Mineral Industries Students at Penn State by John J. Schantz, Jr.
59H20—Colemanite as an Important Source of Borates by William T. Griswold.
59K21—Trends in Real Prices of Representative Mineral Commodities 1890-1957 by Charles W. Merrill.
*59K22—Realignment of the Paley Commission Predictions Over the Next Five Years by S. G. Lasky.
*59K23—Industrial Minerals 1950-1958-1975 With Special Emphasis on Fluorspar by Raymond B. Ladoo.
59F24—Removal of Sulfur Dioxide from Flue Gases at Elevated Temperatures by Daniel Bienstock and J. H. Field.
59B25—Ferrograde Concentrates from Arkansas Manganiferous Limestone by Morris M. Fine.
59F26—Are Coal-Mine Employees and Dollars Protected from Fire as well as Other Industrial Employees and Dollars by R. Ward Stahl.
59AU27—Ground Movement and Subsidence from Block Caving at Miami Mine by J. Fletcher.
59B28—Leaching, Ion Exchange and Precipitation, Blind River Uranium Ore by R. P. Ehrlich, A. G. Roach and K. D. Hester.
59AO29—Firing Fertilizer for Fragmentation by John R. Knudson.
59F30—The Integration of Coal Characteristics with the Design of Large Pulverized Coal Steam Generating Units by Douglas O. Hubert.
*59K31—Light Metals—Prediction and Performance by Walter L. Rice.
59B32—Confirmation of the Third Theory by F. C. Bond.
59B33—Non-sulfide Flotation With Fatty Acid and Petroleum Sulfonate Type Promoters by Stuart A. Falconer.
59F34—A Laboratory Investigation of Flocculation As A Means of Improving Filtration of Coal Slurry by M. R. Geer, P. Jacobson, and H. Yancey.
59B35—The Gyratory Ball Mill, Its Principle of Operation and Performance by A. W. Fahrenwald.
59AO36—Selection of an Open Pit Haulage Method by Wm. N. Matheson.
59B37—Thickening Leach Residues in the Sherritt Gordon Nickel Refinery by S. C. Lindsay and D. J. I. Evans.
59L38—Some Application of Seismic Bedrock Investigations in Ore Prospecting by J. C. Stam.
59L39—Canadian Aero/Newmont Helicopter System As Applied to Massive Sulphide Exploration by R. H. Pemberton.
59L40—Comparison of Plant and Soil Prospecting for Nickel by Chas. P. Miller.
59B41—Refining of Nickel-Copper-Cobalt Mattes by Pressure Leaching and Hydrogen Reduction by V. N. Mackiw, R. F. Pearce, and J. P. Warner.
59B42—Kinetic Study of the Dissolution of UO_2 in H_2SO_4 by M. E. Wadsworth and T. L. Mackay.
59F43—What Can Be Expected From Coal Research? by T. Reed Scollon.
59B44—The Effect of Thermal Treatments On Grindability by F. M. Stephens, Jr. and A. L. Wesner.
59H46—Geology of the Montgary Pegmatite by Richard W. Hutchinson.
59I47—Geochemical Study of Lead-Zinc-Silver Ore from the Darwin Mine, Inyo Co., Calif. by Wayne E. Hall.
*59K48—Iron & Steel; The Paley Report in Retrospect by John D. Sullivan.
59AO49—Transportation Expansion & Improvement in Chuquicamata by Robert Laurich.
59B51—The History of Soap Flotation by George H. Roseveare.
59B52—Two Years of Milling At Bicroft Uranium Mines, Ltd. by D. F. Lillie, W. J. Dengler, and I. C. Edwards.
59H53—Diatomite—A Current Review by Arthur B. Cummins.
59B54—Working the Kinks Out of the Homestake-New Mexico Partners Mill by Clyde N. Garman.
59AO55—Improvements in Loading and Hauling Equipment and Their Effect on Unit Costs by Charles Scott Davis.
59H56—Measurement of Cement Kiln Shell Temperatures by N. C. Ludwig and R. E. Boehler.
59H57—Man-made Industrial Diamonds by J. D. Kennedy.
59B58—Scrubbing of Mesabi Range Intermediate Iron Ores by R. C. Ferguson and William R. Van Slyke.
59B59—Stockpiling Purposes, Methods and Tools by Lawrence O. Millard and S. A. Scott.
59H60—Ammonium Nitrate Blasting in Potash Mining by A. V. Mitterer.
59H61—Modern Classification Methods Applied to Fine Aggregates by Charles E. Golson.
59B62—Flow of Bulk Solids—Progress Report by Andrew W. Jenike.
59B63—Crushing Practices at Reserve Mining Company Operations by A. S. Henderson, E. M. Furness, and F. E. MacIntire.
59AU64—Mining at Gaspe Copper by W. G. Brissenden.
*59K65—Review of Copper, Lead & Zinc Experience Compared With Predictions by Evan Just.
59B66—Belt Conveyor Power Studies by A. W. Asman.
59B67—Consideration of Practical Ore Dressing Problems that are Seemingly at Variance with the Theoretical by C. J. Veale.
59B68—Operation and Maintenance Improvements in a Large Taconite Plant are Facilitated by Good Basic Engineering Design by Robert J. Linney.
59I69—Tectonic Analysis as an Exploration Tool by Peter C. Badgley.
59B70—The R-N Rotary Kiln Process for Reduction of Iron-Ore by O. Moklebust.
59AU71—Algom Nordic Development to Production by E. R. Olson and Murray Airth.
59AU72—Safety Organization at Braden Copper Co. by Stanley M. Jarrett.
59B73—High-Intensity Magnetic Separation of Iron Ores by Ossi E. Palasvirta.
59F74—Determination of Coke Oven Productivity from Coal Charge Characteristics by A. H. Brisse.
59AU75—Long Hole Drilling as an Aid to Mining and Development Work at United Park City Mines Company by G. W. De La-Mare.
59K76—Current Trend of Production and Consumption of Sources of Energy by Eugene Ayres.
59I77—Quantitative Mineralogy as a Guide to Exploration by R. J. P. Lyon and W. M. Tuddenham.
59B78—Flocculation—Key to More Economic Solid-Liquid Separation by Robert H. Oliver.
59A079—Drilling Methods & Equipment at New Cornelia Open Pit Mine by John Edmund O'Neill.
59F80—Mine Communication System at San Manuel by C. L. Pillar.
59B81—Some Design Aspects of Large Uranium Mills by D. J. McParland.
59AU82—Underground Storage for Hydrocarbon Fluids by Robert L. Loofbourow.
59AO83—Blasting with Commercial Grade Ammonium Nitrate at the Utah Copper Pit of the Kennecott Copper Corporation by Laurence E. Snow.
59AU84—A Campaign for the Elimination of Accidents at the Lavender Pit by W. K. Pincock.
59F85—Coal Characteristics and Their Relationship to Combustion Techniques by T. S. Spicer.
59F86—Characteristics of Coal Preparation Plant Slimes by H. B. Charmbury and D. R. Mitchell.
59F87—Safety With Continuous Miners and Other Mechanized Equipment in Pitching Coal Beds by L. H. McGuire.
59B88—The Production of Self-Fluxing Pellets in the Laboratory and Pilot Plant by K. E. Merklin and F. D. DeVaney.
59H89—Trends in the Markets for Mineral Fillers in the Western States by W. F. Dietrich.
59F90—Reducing the Bump Hazard at Sunnyside by L. P. Huntsman and H. H. Elkin.
59A91—The Jackling Lecture—Economic History of the Lake Superior Iron District by Ralph S. Archibald.
59F92—The Advantages of AC Power for Underground Mines by Wendell C. Painter.
59B93—Physical Chemical Aspects of Flocculation by Polymers by Wm. F. Linke and R. B. Booth.
59A94—Industrial Relations—A Service for the Link Organizations by Edmund Flynn.
59H95—Thorite and Rare Earth Deposits in the Lemhi Pass Area, Lemhi County, Idaho by A. Anderson.
59AU96—Mining Problems and Developments at Ambrosia Lake, New Mexico by Donald T. Delicate.
59H97—The Grand Isle Mine—Freeport Sulphur Company's Offshore Venture by Raymond H. Feierabend, Z. Wilson Bartlett, and C. O. Lee.
59AO98—Replacement of Capital Equipment by H. J. Schwellenbach.
59B99—The Wobbler Feeder by T. A. Oberhellman.
59AU100—Pillar Extraction at the Mi Vida Mine by Theodore J. Barrett.
59J101—Exploration Developments by Arthur Brant.
59AO102—Ammonium Nitrate Blasting Agents by Louis W. Towle.
59L103—Anaconda Exploration in the Bathurst District of New Brunswick, Canada by C. G. Cheriton.
59J104—Problems and Developments in Mineral Beneficiation Education by Norman L. Weiss.
59I105—Alhambra Cobalt-Nickel-Silver Deposit, Black Hawk District, New Mexico by Elliott Gillerman.
59F106—AC Power Distribution for Underground Mining by Will Brown Jamison.
59F107—Design for Minimum Maintenance Labor and Supplies by A. P. Massmann.
59B108—Counter Current Decantation—When & Why by E. J. Roberts.
59A109—The Seismic Wave from Plaster and Drill-Hole Explosive Charges by A. W. Ruff.
59H110—Some Remarks about the Washington-Idaho Clay Basin by E. C. Stephens.
59B111—The Magnetic Susceptibility of Rutile and Sphene by S. C. Sun, D. J. Cook, and D. R. Mitchell.
59B112—Single Mineral Flotation with Linolenic, Linoleic, Oleic, and Stearic Acids by Shiou-Chuan Sun.
59B113—Large-Scale Laboratory Investigation of the Ammonium Sulphate Leaching-Hydrogen Reduction Process as Applied to Nicaro Bulk Precipitate by J. F. Shea and O. F. Tangel.
59H114—Rubidium and Cesium—Their Present Status and Their Potentialities by Hung-Kei H. Lam.
59F115—Faults in Pitching Coal Seams—Their Effect on Mining, and Their Solution by Albert M. Keenan.

*Paper given at Council of Economics Session Appraisal of Paley Report.

SME BULLETIN BOARD

Reports of Your Technical Society

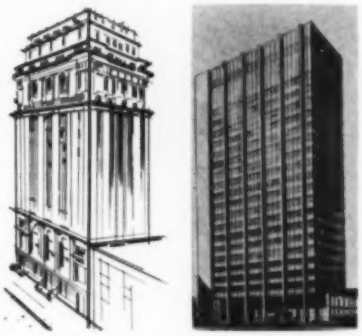
As Mr. McCawber said:

Annual income twenty pounds, annual expenditure nineteen nineteen six, result happiness. Annual income twenty pounds, annual expenditure twenty pounds ought and six, result misery.

For SME's financial story, see p. 539

Mineral Information Section begins on page 476.

THE OLD **THE NEW**



Artist's rendition shows new United Engineering Center to replace present 39th St., New York, building. See page 539 for a report on AIME's progress in the Member Gifts Campaign for funds for construction.

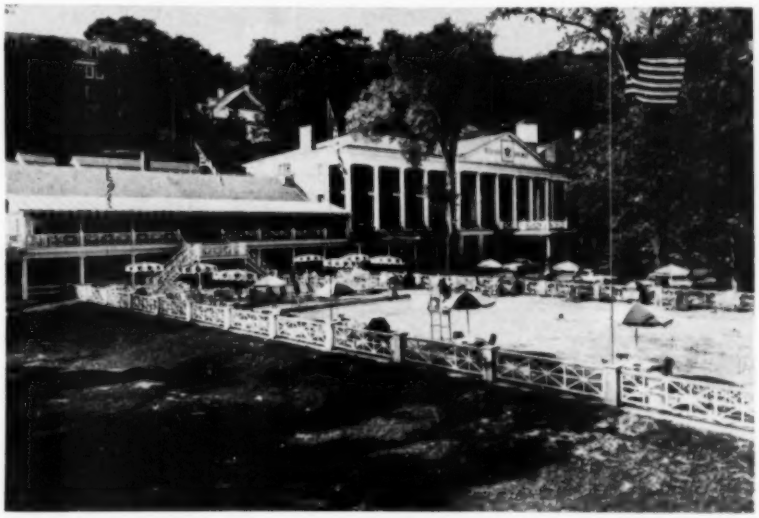
Proposals for Membership

Change of Address Personals Data Boxes

These forms appear on page 547 for your convenience.

Opposite page—*SME's most up-to-date Available 1959 Preprint List. Complete list of available 1958 AIME Joint Solid Fuels Conference papers is available from Preprint Dept., Society of Mining Engineers, 29 W. 39th. St., New York 18, N. Y.*

The Time Is September; Pennsylvania Is the Place



The Bedford Springs Hotel with its new outdoor pool will be headquarters for the Coal-IndMD meeting, September 24 to 26 in Bedford, Pa. See Coal News, page 543, for highlights of papers, topics, recreation, and details for making advance reservations.

NEWSLETTERS . . .

- Coal page 543
- Rock in the Box page 545

AIME

BOARD OF DIRECTORS

Recent actions taken by the Institute Board of Directors

► The Directors expressed appreciation for the bequest of Erle V. Daveler to the Institute. An oil painting of the Bingham Open Pit and $1000 have been left to AIME under the Will of the late benefactor.

► Approval was voted of the establishment of the Williston Basin Section of AIME. Bylaws have also been approved. The Petroleum Section will cover the following counties in North Dakota: Divide, Burke, Renville, Bottineau, McHenry, Ward, Mountrail, Williams, McKenzie, Dunn, Mercer, McLean, Burleigh, Oliver, Stark, Billings, Golden Valley, Slope, Hettinger, and Bowman. In Montana, the following counties are included and have been released by the Billings Petroleum Section: Sheridan, Daniels, Roosevelt, Richland, McCone, Dawson, Wibaux, Prairie, and Fallon.

► Dr. R. F. Mehl has been selected as 1960 Howe Lecturer.

► The Boards of Directors of all three Societies have approved a Major Insurance Policy for AIME employes.

► The establishment of the Saudi Arabia Section has been approved.

► The Arizona Section has approved the formation of the Tucson Subsection and establishment is in order.

► Approval was voted for the appropriation of $1000 in 1959 toward the booklet *Careers in Petroleum Engineering* available to high school and junior college students. John M. Lovejoy, chairman of the Henry L. Doherty Memorial Fund Committee, indicated the committee's approval of the sponsorship for 1959, with the understanding that future sponsorship may also be available.

► Funds are available for presentation of the following Medals and Awards in 1960: James Douglas Medal; Charles F. Rand Gold Medal or Project; Robert W. Hunt Medal; Rossiter W. Raymond Award; Mathewson Gold Medal; Erskine Ramsay Gold Medal; J. E. Johnson, Jr., Award; Robert H. Richards Award; Benjamin F. Fairless Award; Daniel C. Jackling Award; Extractive Metallurgy Division Award; Mineral Industry Education Award; Hal Williams Hardinge Award; William Lawrence Saunders Gold Medal; Anthony F. Lucas Gold Medal. There will be no award of the Robert Peele Award in 1960.

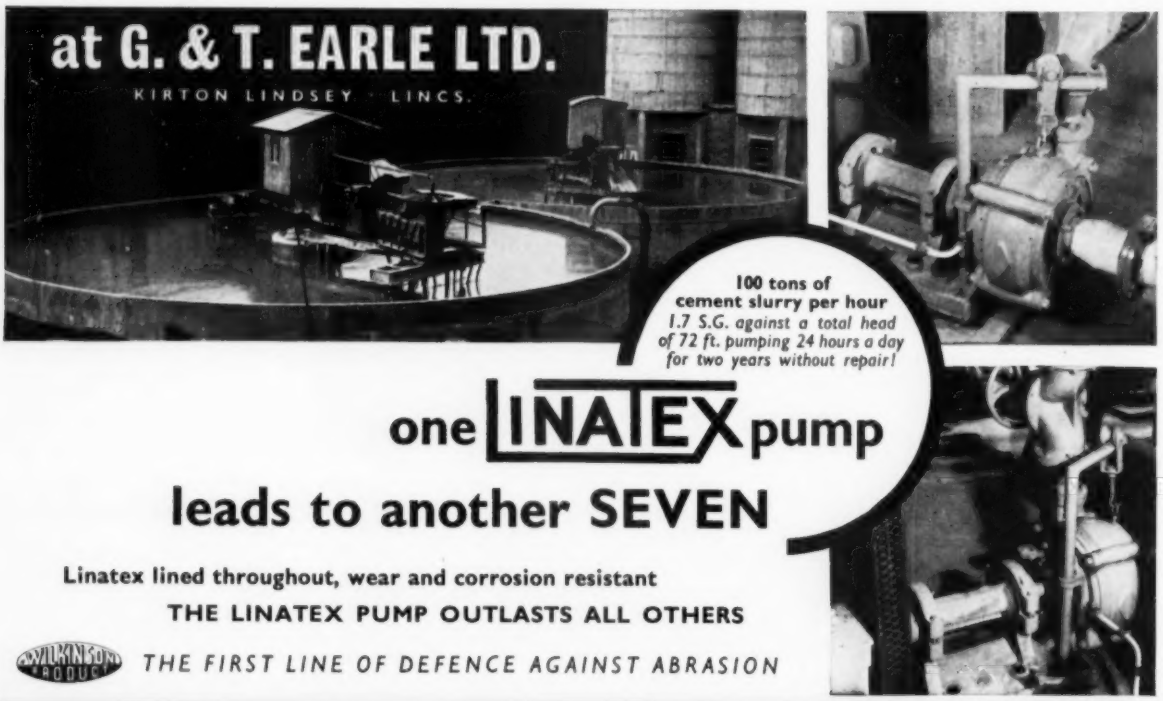
► When Endowment Fund "X" was established, the donor, Henry Krumb, had requested that his contribution be kept anonymous. Prior to Mr. Krumb's death in December he requested that the donor's name be revealed and the name of the fund changed. Subsequently the name was changed to The Henry Kumb Endowment Fund.

► AIME reaffirmed its intention to cooperate in the support of the 1960 Nuclear Congress in answer to a letter from the American Soc. of Civil Engineers.

► The Directors voted to rescind the action of the Board of Directors on Feb. 16, 1958, wherein Student Members were banned in foreign countries where there are no Student Chapters. Therefore, Student Members will be accepted although they may reside in foreign countries without Student Chapters.

► By mail ballot, the Board of Directors has approved changing the date of the June 1959 Board Meeting to Tuesday, June 23, at New York Engineer's Club.

(Continued on page 539)


at G. & T. EARLE LTD.
KIRTON LINDSEY · LINCS.
100 tons of
cement slurry per hour
1.7 S.G. against a total head
of 72 ft. pumping 24 hours a day
for two years without repair!

one LINATEX pump

leads to another SEVEN

Linatex lined throughout, wear and corrosion resistant

THE LINATEX PUMP OUTLASTS ALL OTHERS

WILKINSON PRODUCT — THE FIRST LINE OF DEFENCE AGAINST ABRASION

6 of the 15 Linatex factories in the world. Any of them will see that your enquiries receive energetic attention.

AUSTRALIA	SOUTH AFRICA	CANADA	ENGLAND	MALAYA	U.S.A.
Linatex (Australia) Pty. Ltd., David Street, Dandenong, Victoria, Australia	R. J. Spargo Ltd., P.O. Box 7128, Johannesburg S. Africa	Wilkinson Linatex Co. Ltd., P.O. Box 1310, Station O., Montreal 9, Quebec	Wilkinson Rubber Linatex Ltd., Camberley, Surrey, England	The Wilkinson Process Rubber Co. Ltd., Batu Caves, Selangor, Fed. of Malaya	Linatex Corporation of America, P.O. Drawer D, Stafford Springs, Connecticut, U.S.A.

P62(M)

Local Sections Contribute to New Building

Leaders in AIME Local Section Fund Raising

Name of Section and Assigned Goal	No. Members	No. Pledges Received	Total Amount of Pledges	Average Pledge per Section Member	Average Amount of Pledge	Pct of Membership Pledged	Pct of Goal Attained, April 2
Oregon $1,700	144	52	$5,733	$40	$110	36	337
New York Petroleum $4,065	271	54	11,562	43	214	20	284
Uranium $750	49	19	1,740	35	91	39	232
Penn.-Anthracite $3,300	283	107	5,575	20	52	38	169
Montana $2,700	233	81	3,828	16	47	35	142
Ohio Valley $4,800	419	109	6,516	16	60	26	136
Tri-State $900	76	30	1,150	15	38	16	128
Hugoton $615	41	28	912	22	33	56	122
Gulf Coast $21,960	1464	838	26,510	18	32	57	121
Utah $8,200	711	111	9,565	13	86	16	117
Carlsbad Potash $1,000	89	—	—	11	—	—	100
Florida $2,800	240	31	2,470	10	80	13	88
Black Hills $900	77	25	788	10	31	30	88
St. Louis $5,300	462	46	4,524	1	98	10	85
Arizona $7,100	622	42	5,284	8	126	7	74
Colorado Plateau $2,700	237	54	2,012	8	37	23	74
Philadelphia $4,800	419	34	2,901	7	85	8	60
Niagara Frontier $2,600	225	18	1,400	6	78	8	54
East Texas $2,400	160	56	1,252	8	22	35	52
Mid-Continent $10,935	729	227	5,431	7	24	31	50

On April 2, with the United Engineering Center Building Fund Campaign approaching its final stages, 11 AIME Local Sections had exceeded their quotas and 9 others had achieved 50 pct or better. Almost a quarter of a million dollars had been pledged by AIME members.

The quota for the entire membership of the engineering societies was set as $3 million, industrial companies being budgeted at $5 million, of which more than $4,100,000 had been pledged at the end of March. Of the $3 million from members, AIME agreed to be responsible for $500,000.

Local Sections have assumed the responsibility for approaching their members. Some got an early start, and with good organization achieved their goals without difficulty, though with some earnest canvassing. Perhaps the most difficult job was assigned to the New York Section. Because the new building was to be erected in New York and local pride was involved, and also because the headquarters of many companies is in that city, with a higher proportion of well paid officials, the New York Section was given a goal of $200,000, the total for all of the remaining Sections being $300,000. But the large membership in the metropolitan area of New York, New Jersey, and nearby Connecticut made the appointment of canvassers and their job of reaching individual members a formidable one. Nevertheless, $91,000 had been pledged by the New York Section by the end of March.

Particular credit should go to the 20 Local Sections that have achieved 50 pct of their goals or better. (The goals for other than the New York Section were determined by dividing the $300,000 to be raised by the number of members in each Section on Jan. 1, 1958.)

Board of Directors

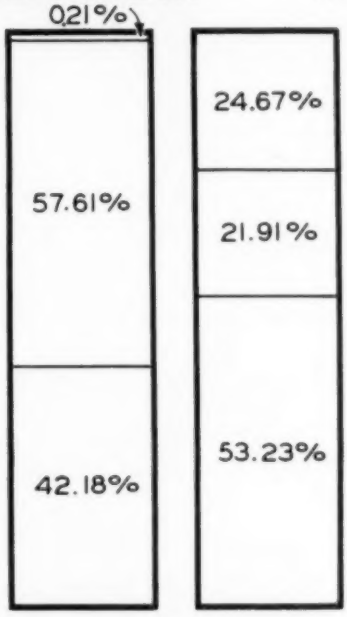
(Continued from page 538)

► The recipients of the Open Hearth Conference Award, 1959, are D. V. Roloff and K. V. Smith for their paper *A Study of Hot-Topping Practice.*

SME'S 1958 DOLLAR

WHERE IT CAME FROM

Other Income	
Interest & Dividends	0.21
Other	0.003
Total other income	0.21 Pct
Dues and Fees	
Current Dues	52.14
Arrears	0.21
New Dues	2.49
Initiation Fees	2.77
Total Dues & Fees	57.61 Pct
Publications Sales	
Advertising Sales	35.64
Journal Sales	2.69
Transactions Volume	2.37
Reprint Sales	0.64
Preprint Sales	0.84
Total Pub. Sales	42.18 Pct
Total Income	100.00 Pct



WHERE IT WENT

Membership & Sections	
Local Sections, Students Delegates Travel etc.	4.59
Society & Divisions	10.73
Sp. Membership	0.54
Meeting & Inst. Act.	7.25
Library Assessment	1.56
Total Membership & Sections	24.67 Pct
General Administrative	
Secretary's Office	7.85
Business Office	9.25
Pensions	2.35
Insurance	0.14
Depreciation	0.76
Miscellaneous	1.30
Directory	0.28
Total Gen. & Admin.	21.91 Pct
Publications	
Advertising Exp.	19.56
Journal Exp.	30.85
Transactions Vol.	1.13
Reprint Exp.	0.53
Preprint Exp.	1.16
Total Publications Exp.	53.23 Pct
Total Expense	99.81 Pct
Excess Income over Expense	0.19 Pct

Education News

Michigan College of Mining and Technology

The mineral research program of Michigan College of Mining and Technology has been greatly expanded by the addition of new equipment. Pilot mill flowsheets on magnetic concentration have been set up with wet drum cobbers, roughers and finishers, a magnetizing block, and 60 to 400 cycle demagnetizing coils. Pelletizing and sintering equipment have broadened the batch test services. And a new high speed moving picture camera, valued at $7,000, will aid fundamental studies in fracturing and flotation.

Michigan Tech's Inst. of Mineral Research was organized in 1955 and housed in a new three-quarter-million dollar building. It has contributed basic research on Michigan ore problems, cooperating with many industrial concerns. A major step forward was taken with the establishment of an industrial advisory committee composed of officials from Michigan's major mineral-producing companies and state agencies. The committee will help coordinate the research efforts of the college and industry.

Russian vs American Education

Another slant on the comparison of Russian and American education systems was offered by Aleksei I. Markushevich, a top Russian educator, after a month-long tour of U. S. schools. According to a *Wall Street Journal* report, Dr. Markushevich asserted that our teaching is often too slow and the work too easy.

Russian students of comparable age and grade are given tougher mathematical problems, more comprehensive science training, and more extensive courses in literature. "We frequently noticed school libraries failed to carry literature needed by secondary school students," he declared.

Russian high school students are given what he termed "a full course" of mathematics—plane and solid geometry, beginning and advanced algebra, and trigonometry. In addition, all graduates have completed four years of chemistry and five years of physics. Many American students take only a single year of chemistry and physics.

Nevertheless, the educator's impressions of the schools were largely favorable and he pointed out that many American educators share his criticism of U. S. science and mathematics teaching.

University of Arizona

• The University of Arizona has been selected by the National Science Foundation to offer a program in research participation for teacher training in the summer of 1959. A grant of $13,950 will assist the university in defraying expenses of the two-month program. Albert B. Weaver, head of the department of physics, will be director. Each of the 10 teachers selected will be able to choose an active research project in progress at the university and will be responsible for an independent part of the project. Interested teachers should apply to Dr. Weaver.

University of Minnesota

Visiting Professor of Mining Engineering for 1959-1960 at the University of Minnesota will be Albert

(Continued on page 541)

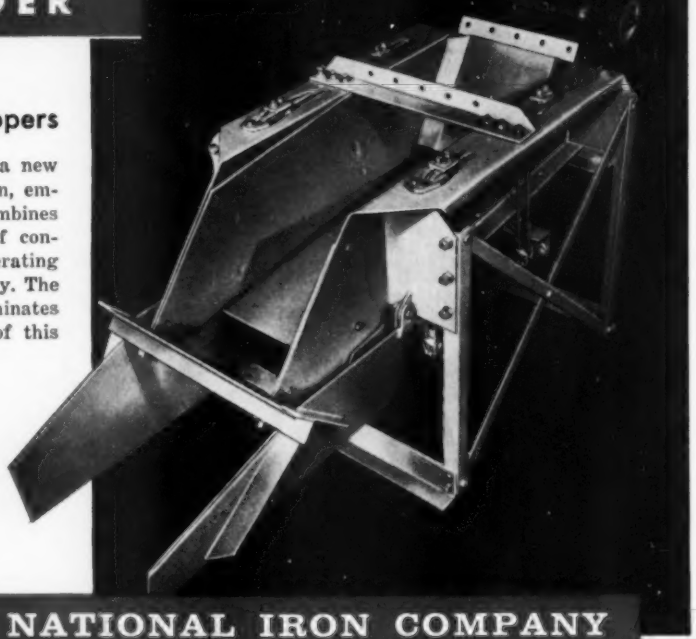
AGU Journal Expands

The rapid growth of basic geophysical research in the United States has prompted the American Geophysical Union and the Dept. of Terrestrial Magnetism of the Carnegie Inst. of Washington to expand its publication *Journal of Geophysical Research*. It will be published monthly and will include scientific papers formerly published in *Transactions, American Geophysical Union*, for better balance of papers in all fields of geophysics.

NICO

RECIPROCATING PLATE FEEDER

Model 500-C



For use under Chutes, Bins and Hoppers

The NICO Reciprocating Plate Feeder is a new concept in reciprocating feeder construction, employing a minimum of moving parts. It combines strength and durability with simplicity of construction and operation to obtain low operating and maintenance costs and higher efficiency. The adjustable four-point suspension eliminates trouble points common to other feeders of this type.

- No rollers to lubricate
- No rollers to stick
- No rollers to wear
- No rollers to replace
- No track to keep clean
- No track to wear
- No track to replace

Write for Illustrated Brochure

NATIONAL IRON COMPANY

30th Ave. West at Ramsey St. — Duluth 7, Minnesota

Personnel

(Continued from page 468)

POSITIONS OPEN

Geologist, field and office. Must have M.S. or better and three to five years experience in geological investigations, surveying and mapping of solid materials formation, both metals and non-metals; must know use of survey collection and record information, make use of published information and prepare maps and sketches. Should know identification and evaluation of mineral resources; will work in remote western areas. Single or limited family status. Salary commensurate with experience, including base pay and expenses. Location, California area. S4200.

Mining Engineer, open pit, preferably graduate, with broad experience in open pit mining at supervisory level, to work as planning engineer for large operation. Two year contract. Salary, about $12,000 a year. Location, South America. S4173.

Mining Engineer, graduate of recognized university. Must have ten years experience as mining engineer or manager or superintendent of operations; able to plan and execute mining program for large new property. Salary open. Location, Wyoming. S4171.

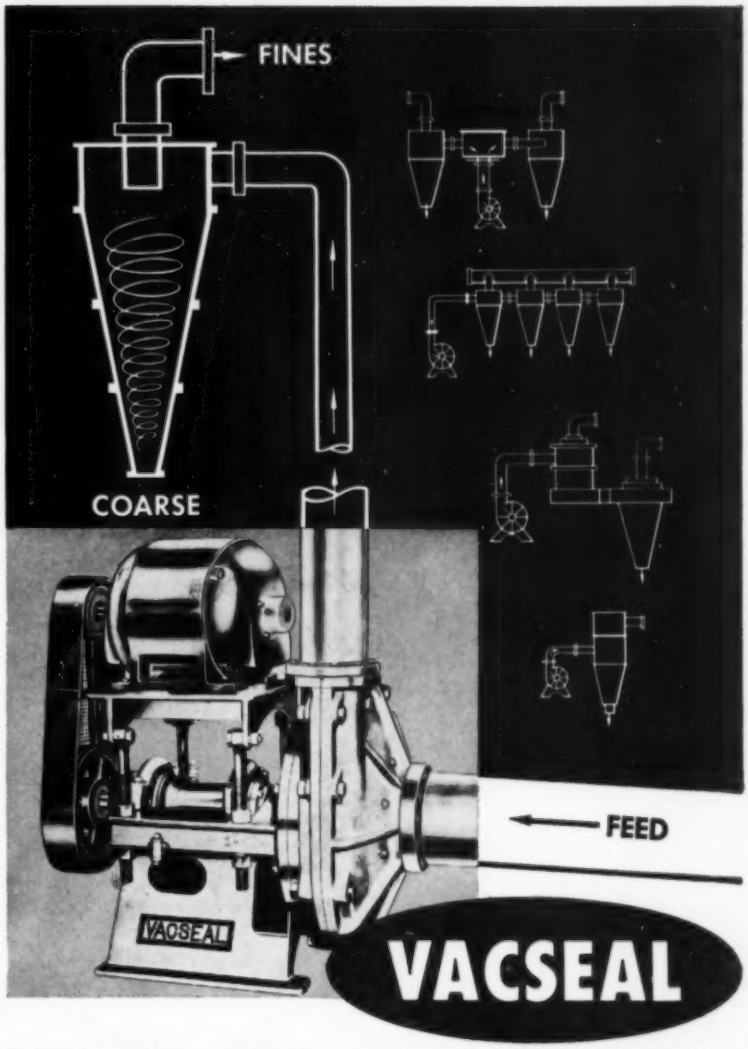
Engineers (a) Mine Manager, copper, zinc, graduate with good experience and record operating medium-sized mines and mills. **(b) Mine Foreman,** preferably graduate, but not essential if man has had 5 or 8 years experience similar work and good record and references. Rate of operation about 220 tpd. **(c) Mill Foreman** with three to five years good experience and operating record as metallurgist for two-flotation circuit mill. Salary open. Location, Arizona. S4216.

Superintendent, mining and milling, graduate E.M., with several years experience in Latin America for small operation of good growth potential. Ag, Au, Pb. Report single status for six months. $8400 U. S. Currency, plus room and board. Location, Mexico. S4209.

Education News

(Continued from page 540)

Roberts, director of the Postgraduate School in Mining, Sheffield University, Sheffield, England. He will present lectures and course work in the area of mine plant engineering, with some emphasis on his specialties of ventilation, lighting, and industrial hygiene. He has written several books on these topics. A lecture tour has been planned for him to visit other engineering schools.



The Preferred Pump for Cyclone Service

In the rapidly developing field of cyclone separation, VACSEAL is enthusiastically accepted as the dependable, efficient liquid-solid pump. It is now being successfully used in many industries, including: coal, sand, chemical and metallurgical as the essential feed unit for the cyclone method of size classification.

The versatile VACSEAL is available in natural rubber, Neoprene, hard iron or all alloy for effective handling of abrasives or corrosives. VACSEAL's unique no-sealing-water feature is particularly desirable for safeguarding against dilution in cyclone separation processes.

We invite correspondence and suggest you write today for literature that gives the reason why VACSEAL Pumps can meet cyclone feed requirements at low cost.

VP-516a

GALIGHER

CONSULTATION · ORE TESTING · PLANT DESIGN

Leaders in Experience and Service

GALIGHER PRODUCTS: AGITAIR® Flotation Machine, VACSEAL Pump, Geary-Jennings Sampler, Acid-proof Sump Pump, Geary Reagent Feeder, Laboratory AGITAIR® Flotation Machine, Laboratory Pressure Filter, Laboratory Ball Mill, Rubber Lined and Covered Products, Plastic Fabrication.

METALLURGICAL DIVISION . . . ENGINEERING SERVICE

The GALIGHER Co.

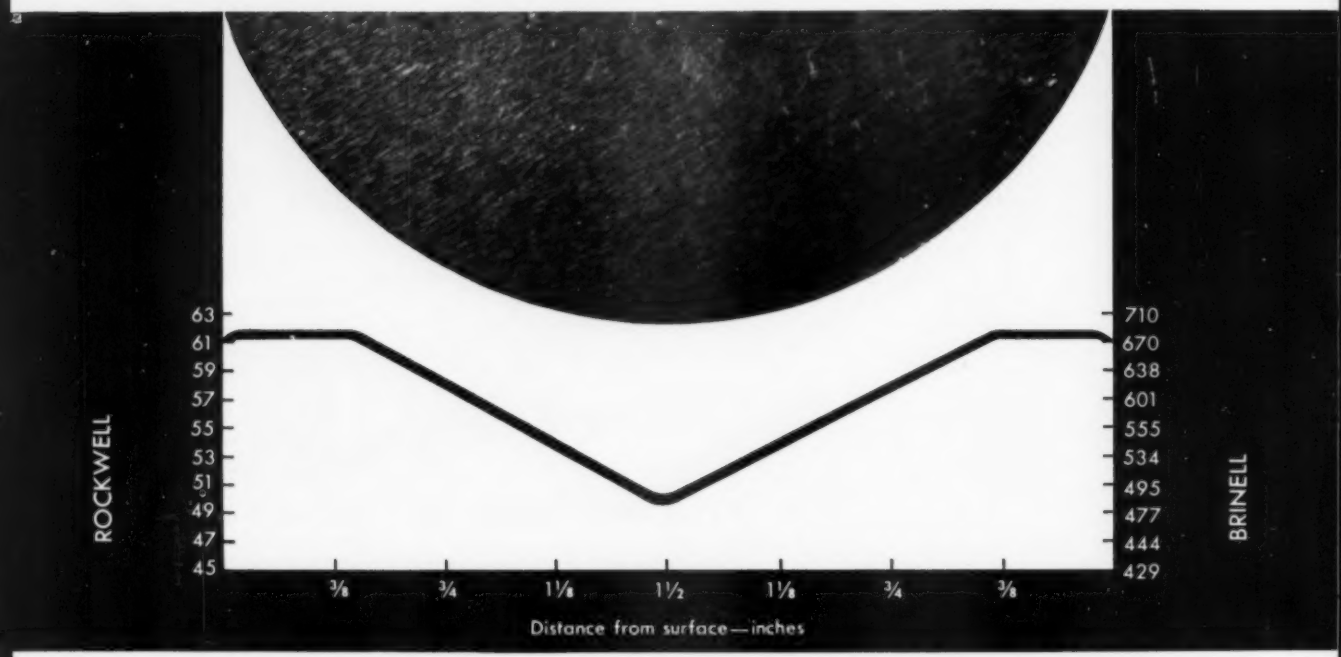
HOME OFFICE: 545-585 W. 8th South, P. O. Box 209, Salt Lake City 10, Utah
EASTERN OFFICE: 921 Bergen Ave. (Room 1128), Jersey City 6, New Jersey

controlled metal hardness means

heat-treated cast alloy steel

NACO GRINDING BALLS

cut per-ton grinding costs



Note how new casting process and full heat treatment show controlled hardness between surface and inner core.

Spectrographic analytical control of elements in steel making processes and controlled heat treatment assure the desired metallurgical grain structure which produce the type of hardness required for maximum wearing qualities.

Performance reports on Naco solid cast alloy steel grinding balls from mills now using them have been universally favorable—both in lasting qualities and impact absorption.

Structurally, they possess a grain closely approaching tool steel—tough, hard and rugged for long lasting qualities. Laboratory tests show a remarkable uniformity in solidity, both under X-ray and specific gravity tests, with controlled hardness holding to a desired depth.

AA-5060

CAPITOL FOUNDRY DIVISION

NATIONAL MALLEABLE and STEEL CASTINGS COMPANY

Post Office Box 750, Phoenix, Arizona

GENERAL OFFICES • CLEVELAND 6, OHIO

Established 1868

FALL MEETING PLANNED FOR COAL - INDUSTRIAL MINERALS DIVS.

A joint meeting of the Coal Division and the Industrial Minerals Division has been planned for September 24 to 26 in Bedford Springs, Pa. High in the Alleghenies, the Bedford Springs Hotel will be headquarters for the visiting conventioners, offering luxurious and informal comfort with a variety of autumn activities.

Outdoor Activities

The rolling Pennsylvania countryside provides every available sport, from golf, tennis, swimming, and shooting, to bicycling, boating, fishing, and riding. The town of Bedford Springs has many historical landmarks for tourists who like to explore. The Hotel itself, first opened in 1804, has large parlor and bedroom suites, attractive dining rooms, and an outdoor pool for warm weather relaxation. Dancing under the stars, wide-screen movies, plus the planned program will keep conventioners busy round-the-clock.

Technical Program

On Wednesday night, September 23, the Hotel will provide free movies for early registrants. Thursday morning, registration will begin in earnest at 9 am and the first technical session will start at 10 am. This will be an industrial minerals session with paper topics covering gypsum, concrete, and dimension stone.

There will be a joint luncheon at noon, then the group will split for a coal technical session and the second industrial minerals session. At six everyone will gather again for a cocktail party, out of doors if the weather permits, sponsored by local industry. The members will be on their own for dinner and evening.

On Friday, combined IndMD-Coal sessions will treat the subject of acid mine water from the political and economic viewpoints concerning the Pennsylvania, West Virginia, Ohio, and Virginia coal mines. A special dinner for the convention will climax the day's activities, with dancing on the terrace if the weather permits.

Saturday will be filled with outdoor events. Tentative field trips for both Divisions are being considered, and a golf tournament has been arranged. The men can turn in their best scores anytime from Thursday morning until Saturday noon for the golf competition. The ladies will receive golf prizes on Thursday afternoon. Their days will be filled with swimming, shuffleboard, bridge, etc., plus the luncheons and dinners planned for the entire convention.

Meeting Arrangements

Advance registration should be made directly with the Hotel. Preliminary arrangements are being handled by Vince Stanton, E. H. Johnson, and John J. Schanz, Jr., who have visited Bedford Springs to discuss their plans with the Hotel management. They have also contacted industrial minerals producers in the Bedford Springs area to invite them to participate as sponsors. Within a 60-mile radius there are producers of glass sand, limestone, ganister, refractory clay, sericite schist, and roofing granules. They will provide a rich source of meeting papers on topics of importance.

Conference Theme

Other subjects of concern to central Pennsylvania are water problems and atomic energy versus coal. From these primary interests a central theme for the conference will be woven to attract all IndMD and Coal Division members. Be sure to follow the announcements of further plans for the meeting during the next few months.

Mining Scholarships

The Central Appalachian Section is offering two scholarships in mining engineering for the school year 1959-1960. Valued at $200 each, the scholarships are available to students who have completed no more than a four-year high school course and have graduated between January and July of this year. Applicants must reside within the Section's portions of Virginia and Kentucky.

For further details, write to Charles T. Holland, Secretary, Central Appalachian Section of AIME, P.O. Box 836, Blacksburg, Va. Deadline for applications is June 30, 1959.

The luxurious yet informal Bedford Springs Hotel will be the setting for the Coal-IndMD Divisions meeting this fall. The main lobby, left, will welcome the conventioners, and the cocktail lounge will invite relaxed get-togethers after the technical sessions.

MORE CORE—LESS COST

TRUCO DIAMOND DRILL BITS
USED THROUGHOUT
THE MINING WORLD

WHEEL TRUEING TOOL COMPANY
3200 W. Davison Avenue
Detroit 38 • Michigan

WHEEL TRUEING TOOL CO. of CANADA, LTD.
575 Langlois Avenue
Windsor, Ont. • Canada

ROCK IN THE BOX

Mining & Exploration Division

Your Program Chairmen Are Depending On You!

Your Division's program personnel are highlighted in this issue of *Rock in the Box*. These are the men putting together next year's Annual Meeting program. They are already well on their way to the highest quality and best balanced M&E program ever, with sessions arranged so that you can get to hear the papers you want to hear. Several key program men got together in February this year to plan ahead, thanks to last year's program chairman, Bob Lacy, and this year's program chairman, Jack Erhorn.

These men will be calling on the members of the Division for ideas, for articles, and for help in various ways. The quality and promptness of the cooperation they get will be reflected in your program next year. The men you have are first rate; give them first-rate cooperation when they call for it and you, the members of the Division, will have the type of program that the largest Division in the Society should have.

The program committee has a detailed schedule to follow this year, in order to block out a program by topics early in the year, to pin down authorship by late spring, and to get papers in early. This will permit session chairmen to study the papers before the meeting, will enable headquarters to send out advance stories and program data that are complete and accurate . . . and so will mean M&E papers can be preprinted in time. Let's go to it.

The five Unit Program Chairmen are:

Underground—G. S. Arentz, Jr., 870 First Security Bldg., 405 South Main St., Salt Lake City, Utah.

Open Pit—Howard A. Wilmeth, Chino Mines Div., Kennecott Copper Corp., Santa Rita, N. M. Mr. Wilmeth has been with Chino Mines Div. for seven years, serving as an underground engineer in charge of underground zinc mines, as an industrial engineer, and presently as mine engineer. He is a licensed professional engineer and land surveyor. For three years he worked as production foreman with Anaconda in Potrerillos, Chile. A graduate of New Mexico School of Mines, he received his B.S. in mining engineering in 1947. During World War II he was a pilot in the U. S. Air Force.

H. A. WILMETH

R. H. CARPENTER

Geochemistry—Frank C. Canney, USGS Bldg., Federal Center Bldg., Denver, Colo.

Geology—Robert S. Carpenter, Colorado School of Mines, Golden Colo. Mr. Carpenter is a professor of geology in charge of economic and mining geology. For the past five years he has been engaged in a consulting capacity for the Thompson Creek Coal and Coke Corp. in addition to other consulting positions. He recently returned from a year's stay in Florence, Italy, as a Fulbright Research Scholar. During the period of 1957-1958, he carried out research investigations of hydrothermal dispersion in carbonate rocks in South Central Europe.

His career in geology was the "aftermath" of his education which included graduation from Stanford University in 1941 with both B.A. and M.A. degrees in geology. He attended Princeton University in 1941-1942 and four years later returned to Stanford to receive a Ph.D. in geology and mining in 1947.

Doctor Carpenter's education has been accompanied by almost continuous endeavors in the mineral industry. This experience includes working in mines, mills, and subsequently as a consulting geologist.

In 1947 he was engaged by the Colorado School of Mines on the faculty, where he is at present. The various companies who have engaged him as a consultant include the New York & Honduras Rosario Mining Co. in Central America, the Molybdenum Corp. of America, the Utah Construction Co., and Eastern Mining and Metals Co. Ltd. of Singapore.

Geophysics—Warren H. Westphal, Utah Construction Co., Box 1590, Salt Lake City, Utah. Born in Easton, Pa., Mr. Westphal attended Colorado School of Mines and Columbia College, graduating in 1947. He worked as junior mining engineer, geologist, and geophysicist for The New Jersey Zinc Co. from 1947 to 1955 in Franklin, N.J.; Palmerton, Pa.; and Gilman, Colo. He joined Utah Construction Co. as a senior geologist in 1956 and is currently consulting geophysicist in the Engineering and Geology Dept. at Salt Lake City. He is a member of the Soc. of Exploration Geophysicists.

EDITOR

Address news items to:

John W. Chandler, American Metal Climax Inc., 61 Broadway, New York 6, N. Y.

Since 1885—Gruendler Quality
The Best That Money Can Buy

Your Crushing Problem Solved!

Here you see two types of GRUENDLER CRUSHERS made in a wide range of sizes and capacities for the crushing of Rock, Minerals, Ore, and Gravel. Write Dept., ME-559 for BULLETINS. Mention nature of material to be crushed, size of finished product and tons hourly wanted.

Heavy Duty Roller-Bearing JAW CRUSHER Longer jaws and simple adjustment feature

Heavy Duty Roller Bearing DOUBLE ROLL CRUSHER Spring tension adjustment

GRUENDLER CRUSHER and PULVERIZER CO.

2915 N. Market St., St. Louis 6, Mo., U.S.A.

Around the Sections

• The **Lima Peru Section** celebrated New Mexico School of Mines Day on March 18 at the American Room of the Hotel Bolivar. The education committee of the Woman's Auxiliary planned the program to explain the work and future of the committee. Mrs. John Burgess told about the students who have received scholarships through the efforts of the committee.

• The **University of Utah Student Chapter** and the **Student Affairs Committee** of the Utah Section were hosts to the Section officers and executive committee at a smorgasbord dinner, Friday evening, March 6. Richard Knostman, president of the Student Chapter, presided at the informal affair.

• The **Upper Mississippi Valley Section** held its annual dinner meeting at the Village Bar in Kieler, Wis., on January 28. Roy W. Kopp was the guest speaker, discussing the activities of the Emergency Lead-Zinc Committee during the recent Tariff Commission and Legislative Committee hearings in Washington.

• The **San Francisco Section** welcomed Pete Fowler of the Kaiser Engineers Overseas Corp. for a talk on conditions in India for exploration and development in the mineral industries. The meeting was held at the Engineers Club on March 11.

• The **Golden Gate Petroleum Subsection**, San Francisco Section, met on March 19 at the Bellevue Hotel. Irving Fatt, associate professor at the University of California, spoke on *Possible Use of Underground Atomic Explosions for Recovery of Oil.*

• The **Ajo Subsection,** Arizona Section, held their monthly meeting on Jan. 8, 1959, with R. E. West presiding. Joining in the discussion of sessions attended at the annual regional meeting in Tucson were T. R. Herndon, J. E. O'Neill, F. E. Rickard, and H. M. Hoppe.

• Guest speaker for the **Cleveland Section** on March 19 was Richard J. Lund, Battelle Memorial Inst. He discussed creating future demands for uncommon metals. Cocktails and dinner preceded his talk.

• The annual Ladies Night of the **Chicago Section** on March 4 featured a talk by Eldred E. Green on landscaping. Members of the Women's Auxiliary were guests.

• The **Florida Section** March 2 meeting presented a symposium on dust control methods. A barbecue was planned for April.

• The **St. Louis Section** listened to a talk on Central Africa by G. Donald Emigh on March 13 at the Hotel York. D. Emigh is director of mining for Monsanto Chemical Co.

• The **El Paso Section** met at the Hotel Cortez, March 11, with Robert McGeorge presiding. Ralph K. Johnson, Western Knapp Engineering Co., spoke on construction of Kennecott's copper smelter at Hayden, Ariz., illustrating his talk with slides and films.

• Guest speaker at the **Utah Section** meeting, March 19, was Adolph Soderberg, Kennecott Copper Corp. He discussed elements of long range open pit planning. The meeting was held at the Newhouse Hotel in Salt Lake City.

• A joint meeting with the ladies and the **Colorado Section** was held at the University Club in Denver. Members and wives gathered for a social hour before dinner, and after a short business meeting, James B. Flaherty gave a talk on fashions for 1959 while Mrs. Flaherty modeled the new dresses and hats.

Lima Education Group Provides Scholarships

Achievements of the Education Committee of the Lima Peru Section set an example for other Sections to follow. Mrs. John Burgess, committee chairman, recounted the progress of the five-year-old plan for obtaining scholarships for deserving students, at the March meeting of the Section. The committee members have gained great satisfaction in helping 14 students obtain engineering educations.

The local program was patterned after the National Committee of the Woman's Auxiliary. Candidates are interviewed in the members' homes, after an investigation of their qualifications. They are often recommended by the Reactor of the University, or by other scholarship students. The financial support continues as long as high standards are maintained. So far several students have graduated at the top of their class.

The committee searches for contributions from industry, or for other special loan funds, often with a particular candidate in mind. The first student to receive a four-year scholarship in Lima recently obtained his Master of Petroleum Engineering Degree from the University of Oklahoma in one year, with the continued support of the committee who had followed his progress.

The chairman of the Education Committee, Lima Peru Section, Mrs. John Burgess, describes to Local Section members the activities, aims, and accomplishments of her committee at the March meeting. The excellent report told the story of 14 young engineers who have been helped financially to obtain their education. Here at the head table are seen, left to right, Mrs. Dorothy L. Smith; Mrs. Lily D. Ballon; Mrs. Zita Fleischman; Alberto H. Barrios, Section chairman; Mrs. Mina Burgess; Walter E. King; Mrs. Grace Cadwell; and Mrs. Dawne Entwistle, the women who did the work.

Personals

Roger Pierce was on a consulting assignment in the Lake Ambrosia area in November and in the Blind River district in Canada in January also in connection with consulting activities.

Christian H. Aall has been promoted from director of research at American Metal Climax Inc. to manager of copper, smelting, and refining operations.

Jack H. Bookey, formerly geologist for The Anaconda Co., had become assistant U. S. District Attorney for Montana. He completed his study of law at Montana State University last June.

Reginald G. Ryan has resigned as chairman of the department of geology at Midwestern University. He will be associated with Ryan, Hutchinson and James, a new firm of consulting geologists in Wichita Falls, Texas.

J. F. Wickham has been transferred as mill superintendent to the Chilete Unit of the Northern Peru Mining Corp., a subsidiary of Asarco.

J. A. Townsend has left Mufulira Copper Mines Ltd., Rhodesia, and has taken the position of mine agent with the Indian Copper Corp. Ltd. in India.

Kennecott Copper Corp., Utah Copper Div., announced promotions for **Neil Plummer** and **J. W. Ribotto.** Mr. Plummer was the mills metallurgical engineer and now is superintendent of the Arthur milling department. Mr. Ribbotto, former superintendent of the mills service department, was promoted to mills metallurgical engineer.

Nemesio Arancibia Rojas, formerly with Paulino Callejas e Hijos, now is employed by Compãnia Minera Tamaya S. A. as administrador in Establecimiento Minero Las Chivas.

D. C. Wysor has rounded out 45 years as a geologist for General Chemical Div. of Allied Chemical Corp. and is retiring, with the intention of opening a consulting office in New York.

J. V. ROY

P. L. WEINHEIMER

The appointment of **James V. Roy** as sales manager has been announced by Singmaster & Breyer Inc., New York chemical and metallurgical engineering affiliate of the Fluor Corp. Ltd. of Los Angeles.

Paul L. Weinheimer has been assigned as a safety products sales engineer in San Francisco for Mine Safety Appliances Co., Pittsburgh. He had been serving in a similar capacity in the Akron, Ohio, area, where he will be succeeded by **Richard A. Yost** who had been associated with the firm's safety products marketing services.

Wen-Lan Chen is engaged in design and construction of a crushing stone plant for Western-Knapp Engineering Co. His previous job as research engineer for Link-Belt Co. prepared him for this position as principal metallurgical engineer.

R. S. Walker, consultant for The M. A. Hanna Co., completed 50 years

PROPOSAL FOR AIME MEMBERSHIP

I consider the following person to be qualified for membership and request that a membership kit be mailed to him:

Name of Prospective Member:

.....

Address

.....

.....

.....

Name of AIME Member:

.....

Address

.....

.....

.....

SME

CHANGE OF ADDRESS AND PERSONALS FORM

CHANGING YOUR ADDRESS? Don't forget to notify us six (6) weeks before you move, if possible, to insure uninterrupted receipt of your publications and correspondence. Please fill in the form below and send it to: J. F. Lynch, Asst. Treasurer AIME, 29 West 39th Street, New York 18, N. Y.

Name .....

Old Address .....

.....

.....

New Address .....

.....

.....

PERSONALS: Please list below your former company and title and your new title and company (or new work) for use in MINING ENGINEERING. (Copy deadline for personals items is six weeks before date of issue.)

Former Company .....

Former Title ..... Length of Time There .....

New Company .....

New Title ..... Date of Change .....

.....

Any recent activity that would be of interest to members:

.....

.....

.....

personals

continued

of service with the company last August and retired at the end of the year. He had contributed many original applications in the field of ore and coal mining.

Quenton L. Brewer, formerly assistant to the manager of Swinerton & Walberg Co., service contractor to the Atomic Energy Commission, now is a consultant to H. J. Vander Veer & Assocs. in Salt Lake City.

C. DeWitt Smith has resigned from Copper Range Co. where he had been vice president in charge of mining operations, and has established a mining consultant business in Lincoln, Mass.

Grover J. Holt, assistant to the president of Cleveland-Cliffs Iron Co., received an honorary doctorate in engineering from the University of North Dakota.

William J. Waylett has moved from Tel Aviv to Ankora as mining advisor to the U. S. Operations Mission to Turkey. He is responsible for the administration of the entire minerals program in both the technical and economic assistance programs. He succeeds **Christopher W. Ryan,** who will take over Mr. Waylett's post in Tel Aviv. The field offices are part of the International Cooperation Administration.

S. Power Warren has changed his address from 1400 Pierce Street, Lakewood, Colo., to 914 19th Street, Golden, Colo., where he will continue his consulting work.

Bunting S. Crocker, chief metallurgist for Kilborn Engineering Ltd., was named vice president of the firm. His home is in Toronto.

Stewart E. Poet, formerly a geologist for the St. Joseph Lead Co., now is self-employed in mining at Cripple Creek, Colo.

Robert Shafer, engineer for American Smelting and Refining Co., Page mine, Kellogg, Idaho, recently returned from a visit to company operations in Columbia and is with South American Gold & Platinum Co.

Harold W. Sorstokke, formerly junior metallurgist, Miami Copper Co., has become testing engineer for Inspiration Consolidated Copper Co. in Arizona.

Tien-Shih Liu, who was a senior research metallurgist for Titanium Metals Corp. of America in Henderson, Nev., now is consulting metallurgist for Southwest Research Inst., San Antonio, Texas.

George Magnuson is now working as mining engineer at the Montreal mine of the Oglebay-Norton Co., Montreal, Wis.

Archie P. Cochran, president and founder of Cochran Foil Co., has been elected president of Anaconda Aluminum Co. which was formed by a merger of his firm with American Aluminum Co. The new firm will be located at Louisville, Ky.

W. K. DALY A. P. COCHRAN

W. Kenneth Daly, vice president and comptroller of The Anaconda Co., retired in December after a long association with the firm as a key figure in its accounting and financial affairs. He joined Anaconda in 1917, became comptroller in 1940, and vice president in 1956. The assistant comptroller, **William E. Quigley**, has been elected to succeed him. **David R. Nelson,** formerly assistant secretary-assistant treasurer, will become the new assistant comptroller, and **William J. Fogarty** will succeed Mr. Nelson. **Richard L. Cooney,** assistant comptroller of the South American subsidiaries, has also been named assistant comptroller of The Anaconda Co.

John B. Knaebel has been appointed president and managing director of Anaconda Iron Ore Ltd. He has headed many exploration projects for the firm in the 13 years he has been associated with Anaconda. Mr. Knaebel was awarded the AIME Saunders Medal at the Annual Meeting. For a report of his career activities see the January Rock-in-the-Box.

W. E. QUIGLEY J. B. KNAEBEL

Theodore M. Szmyd, mine engineer for American Cement Corp., Riverside Cement Co. Div., has been promoted to assistant to superintendent.

E. E. Leitch, formerly New Caledonia representative for Quebec Metallurgical Industries Ltd., now is mill superintendent for South Alligator Uranium N. L. in the Northern Territory of Australia.

D. W. Fuerstenau, formerly research engineer, metals research laboratories, Electro Metallurgical Co., Niagara Falls, now is manager of mineral engineering, Kaiser Aluminum and Chemical Corp., Permanente, Calif.

Raymond E. Whitla has transferred into the Office, Chief of Engineers, U. S. Army Engineers, Washington, D. C.

William Eathorne retired last June from the U. S. Bureau of Mines and has been travelling extensively before settling down to a consulting practice as a safety consultant on static electricity at his home in Pittsburgh.

Karel Roos, engineer for Northern Peru Mining Corp., has become chief engineer at the Quiruvilca Unit of the firm, located in Trujillo, Peru.

Richard L. Brown, Jr., spent the winter on loan to Asarco's southwest mining department in Tucson. He is a mine geologist for Buchans Mining Co., subsidiary to American Smelting and Refining Co. in Buchans, Nfld.

B. S. CROCKER D. R. NELSON

Charles B. Bradford used to work for Southern Peru Copper Corp. at Denver and now is associated with Kennecott Copper Corp. at the Ray Mine Div., Hayden, Ariz.

Robert G. Billings has transferred from engineering and production to potash sales for the midwest sales office in Peoria of the Potash Co. of America.

David Sharpstone, mining consultant, is now in Toronto after spending ten months in the Rhodesias, Uganda, and Ethiopia on professional work.

Three new appointments at Inland Steel Co's iron ore mining operations have been announced: **Philip D. Pearson** was named manager with headquarters in Ishpeming, Mich.; **Peter P. Ribotto** became manager of Caland Ore Co., Atikokan, Ont.; and **Douglas E. Brown** was appointed chief engineer of iron ore mines. Mr. Pearson was formerly manager of Caland Ore Co.

Errol M. Kennedy was appointed inspector of mines with the Fiji Government and is head of the Lands, Mines and Surveys Dept.

George W. Mitchell, Jr., formerly a miner at Stanleigh Uranium Corp. Ltd., now is a student at the Graduate School of Business, Stanford, Calif.

H. R. King has been appointed deputy director-general of reconstruction in London of the National Coal Board. He had been reconstruction director of the Scottish Div. As director-general Mr. King is primarily responsible for the preparation of all standards of layout, major equipment and buildings related to new sinkings and reconstruction projects, both underground and on the surface.

Harry M. Feigin of International Minerals & Chemical Corp., Skokie, Ill., has become assistant manager for production in Bartow, Fla. He was organization planning coordinator, and in his new capacity is in charge of all production operations of the Florida Minerals Dept., Phosphate Div.

Hon Chi Li, formerly a graduate student at Massachusetts Inst. of Technology, now is research engineer at Duval Sulphur and Potash Co., Carlsbad, N. M.

Robert C. Bacon has become general superintendent of operations for Braden Copper Co. He had been vice president of Ventures Ltd., and district engineer for C. F. Braun & Co.

Lester F. Engle, Jr., formerly process engineer for Cuban American Nickel Co. which is now Freeport Nickel Co., will be leaching superintendent for Moa Bay Mining Co., a subsidiary, when operations commence at the new plant in Santiago de Cuba.

Peter B. Hobsbawn, who was concentrator general foreman for The Chile Exploration Co., now is superintendent in charge of metallurgy for Andes Copper Mining Co. in Potrerillos, Chile.

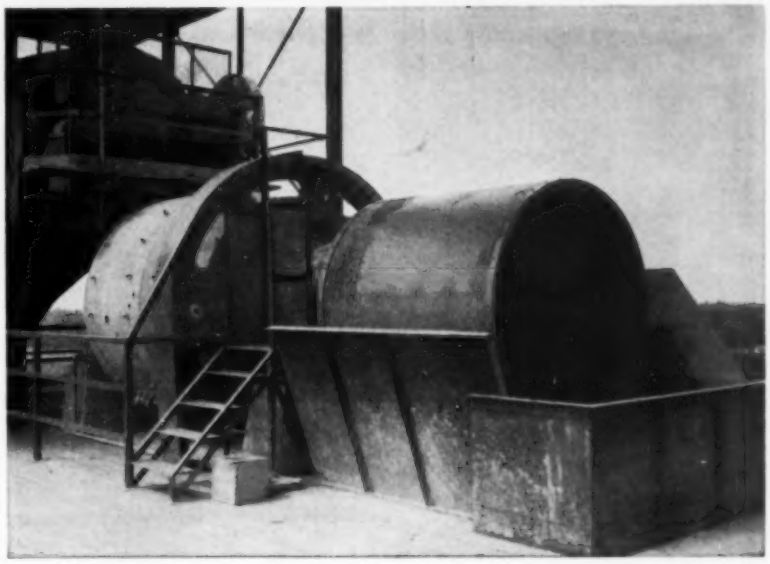
E. Willard Berry, professor in the geology department of Duke University, Durham, N. C., is studying the coals of Australia this summer and will be back in the U. S. in September.

Robert I. Williams of Kennecott Copper Corp. has transferred from the Ray Mines Div. where he was pit equipment maintenance foreman, to the Utah Copper Div. in Bingham Canyon, where he is general shop foreman. His home is in Salt Lake City.

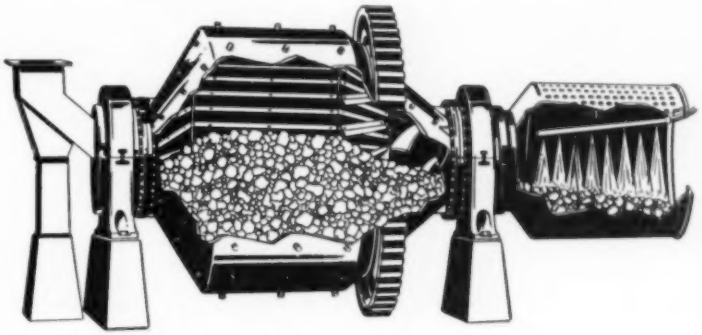
Francis F. Redfield, St. Joseph Lead Co., has moved from Mine La Motte to Viburnum Div., Via Courtois, Mo., and continues to be division superintendent.

J. R. Sweet, formerly vice president and general manager, Tungsten Min-

HARDINGE SCRUBBERS FOR PIT-RUN MATERIALS



The 8′ x 48″ Hardinge Conical Scrubber, above, with 6′ x 6′ dewatering screen kept a west coast sand and gravel firm in business, after their high grade deposit was exhausted—successfully removing large quantities of extremely sticky clay from their quarry stone. Hardinge Conical Scrubbers are in operation throughout the country, cleaning crude iron ore, sand, gold ore, dolomite, river gravel, and crushed stone of all types.



Large diameter, short length trunnions permit chute feeding of unsized ore and rock at rates up to 600 tons per hour.
The mass loading and ball-mill action in the scrubber quickly and completely slurries the clay and dirt, permitting ready separation on washing screens or trommels.

Write for Bulletin 37-B-2

HARDINGE
COMPANY, INCORPORATED
YORK, PENNSYLVANIA • 240 ARCH ST. • Main Office and Works
New York • Toronto • Chicago • Hibbing • Houston • Salt Lake City • San Francisco • Birmingham • Jacksonville Beach

■ Product preparation is the strongest single influence on your weekly sales, monthly volume and annual profit. If ordinary screens are giving you ordinary product quality, find out how Bee-Zee Screens are the difference between problems and profit.

Bee-Zee Screens make you money through sharper sizing, better dewatering or deliquefying, non-clogging action and resistance to abrasion. They are stainless steel, precision welded to form the right size, right shape and right dimension screen for your operation and equipment.

Talk to your screening equipment manufacturer about Bee-Zee Screens. Or, write, wire or phone DIckens 2-5154 collect.

ROUND-ROD SCREEN
long-life accuracy

GRIZZLY ROD SCREEN
rugged accuracy

ISO-ROD SCREEN
prolonged accuracy

TRI-ROD SCREEN
knife-like accuracy

GRIZZLY ROD WITH SKID ROD
ruggedest accuracy

BIXBY-ZIMMER
ENGINEERING COMPANY
459 Abingdon Street, Galesburg, Illinois

personals

continued

ing Corp.'s Hamme mine in Henderson, N. C., resigned his position and has retained a consultant basis with the company. He has established temporary residence at Menlo Park, Calif.

A. T. Rusk, mining engineer, has left Phelps Dodge Corp. to join Southern Peru Copper Corp. where he is working on development of the Toquepala ore body.

Jesse A. Miller, formerly market analyst for International Minerals and Chemical Corp., now is in market development for E. J. Lavino & Co., with his home in Willow Grove, Pa.

Raymond V. Kettner transferred from International Smelting & Refining Co. where he was superintendent of concentrator, to The Anaconda Co. where he is in metallurgical research at Anaconda, Mont.

W. E. Field, formerly manager, National Explorations Ltd., now is manager of Carol Metal Mines Ltd. in Whitehorse, Canada, exploring the Yukon for molybdenum.

H. W. Hitzrot, Jr., is working in the research department of Bethlehem Steel Co., having just completed two years military service. He is an engineer's assistant in Bethlehem, Pa.

Charles B. Leonard, who was engineer parachute officer in the U. S. Army, now is shift foreman for Andes Copper Co., El Salvador, Chile.

John M. Norlin has been transferred to the main office of The W. S. Tyler Co. at Cleveland from Birmingham, where **John Craig** is now representing Tyler in the southeast. Mr. Norlin is a sales engineer, and Mr. Craig formerly was with Heavy Minerals Co. in Aiken, S. C.

John W. Svanholm has completed a second contract term for the Burmese Government, the Mineral Resources Development Corp., as consultant. He discovered the first uranium-thorium deposit in Burma. Presently he is doing some work at Stockholm University prior to leaving for the U. S.

Richard A. Brown, technical representative for Carbide Chemicals Co., has transferred from the Montreal to Toronto office.

Olav Mellgren consulting engineer for Titania A/S Hauge, Norway, is lecturing at the Royal School of Mines, London.

C. C. Huston and Associates, Toronto, have been retained by Phillips Petroleum Co. at their Mining and Milling Dept. operations in the Ambrosia Lake district, Grants, N. M. **C. C. Huston** and **Herbert H. Cox** have visited the Phillips uranium properties as general mining consultants.

Raymond C. Blest, formerly assistant plant superintendent for Kaiser Bauxite Co., now is general foreman of dock and raw materials for Kaiser Aluminum & Chemical Corp. at the company's new alumina plant on the Mississippi, Gramercy, La.

H. S. McGowan, president of La Luz Mines Ltd., has moved to the head offices of Ventures Ltd. in Toronto to become vice president and general manager of the parent firm.

Wendell W. Fertig, executive vice president and general manager, Western Nuclear Corp., has resigned to devote his entire attention to collaborating with John Keats on memoirs of the guerrilla operations in the southern Philippines during World War II. His story concerns a small group of Americans who took an island from the Japanese and maintained schools, courts, a postal system, and other standards of peaceful civilization, 1200 miles behind the lines.

Otis M. Clarke, Jr., has moved from Little Rock, Ark., to Oakland, Calif., where he is now project geologist for Kaiser Aluminum & Chemical Corp. He was a geologist for Reynolds Metals Co. His Oakland address is 1924 Broadway.

William P. Morris, who was a metallurgist for the Atomic Energy Commission in Grand Junction, Colo., now is general manager of New York and Honduras Rosario Mining Co., living in San Pedro Sula, Honduras.

J. E. Van Dell, formerly of Dravo Corp., is an engineer at Concrete Conduit Co. in San Gabriel, Calif.

William Devitt is a tram and quarry engineer for the U. S. Gypsum Co. He had been a graduate student at Colorado School of Mines. Now he is located in Empire, Nev.

H. A. Byrns, formerly general superintendent, blast furnaces-by product and transportation for Woodward Iron Co., Woodward, Ala., now is consulting and training in operations for Siderurgia Argentina in San Nicolas, Argentina.

G. Gregory Bryan, National Lead Co., has been transferred to Buenos Aires, Argentina as production manager. He has been with the New York firm for three years.

William C. Greenleaf, formerly manager of metals sales and devel-

opment, U. S. Industrial Chemicals Co., New York, now is director of marketing for Harvey Aluminum in Torrance, Calif.

M. D. Hassialis, head of Columbia University School of Mines, was elected president of Pacific Uranium Mines Co. Dr. Hassialis is also director of the Columbia University Beneficiation Laboratory, operated for the Atomic Energy Commission.

Guy H. Ruggles, formerly director of concentration for Cananea Consolidated Copper Co., retired in January but will act as consultant in matters of concentration and is planning to move to Phoenix, Ariz.

H. J. Tillia will continue as director of Eastern Mining and Metals Co., although now he is self employed as consulting geologist, after working in Malaya for six years.

R. L. Tobie, who has been superintendent for Cleveland Cliffs Iron Co. for over six years, now is planning engineer for San Manuel Copper Corp. in Arizona.

John E. Riddell, associate professor in the department of geological sciences at McGill University, has become professor and chairman of the department of geology at Carleton University, Ottawa, Ont., where he will continue research in geochemistry as applied to mineral exploration.

Eugene T. Moroni had been chief engineer and general superintendent for Bell & Zoller Coal Co., and has become general superintendent for Coal Processing Corp.

D. Macleod became metallurgical superintendent for Rhokana Corp. Ltd., Nkana, Northern Rhodesia, in March.

Howard A. Wirtz, formerly assistant chief, geological exploration, Cerro de Pasco Corp., now is engaged in the development of mining methods for Hughes Tool Co., Special Applications Dept., Houston.

Two advancements at Reserve Mining Co. were the promotion of **James A. Reynolds** to superintendent of the crushing and concentrating department, and of **William P. Pearson** to assistant superintendent.

Min-sheng Huang graduated from New Mexico Inst. of Mining and Technology with a B.S. in mining engineering and is now a graduate assistant in the Dept. of Mining Engineering at Virginia Polytechnic Inst., Blacksburg, Va.

August J. Breitenstein has been appointed assistant vice president, raw materials, for U. S. Steel Corp. He has been director of exploration and planning since 1954.

Howard M. Graff was appointed general manager of raw materials of Inland Steel Co. He had been manager of Inland's iron ore mines in Ishpeming, Mich., and will move to the headquarters in Chicago.

Eugene C. Anderson, consulting mining engineer-geologist in Socorro, N. M., has opened new offices at 130 Center St. following a fire that destroyed his old offices.

Roshan B. Bhappu has joined the New Mexico Bureau of Mines as senior staff metallurgist. Originally from Pakistan, Dr. Bhappu has been project engineer for Colorado School of Mines Research Foundation Inc. and metallurgist, Miami Copper Co.

James M. Deatherage was separated from military service last year and is currently employed by The New Mexico Inst. of Mining and Technology as an assistant field engineer and security officer.

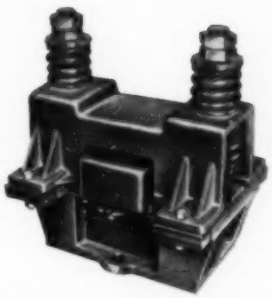
D. Kerr-Cross is in India under the United Nations Technical Assistance Administration and expects to remain there for over a year.

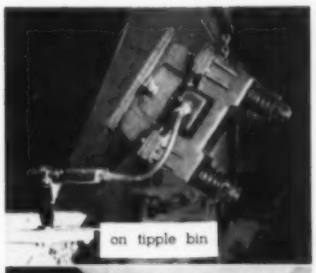
C. J. Flippen has retired from his position as Labor Commissioner, Kanawha Coal Operators' Assn., in Charleston, W. Va. He will do some consulting work on labor relations. He has been commissioner since 1945.

SYNTRON

Pulsating Magnet

BIN VIBRATORS





reduce costs and increase production, eliminate build-up, sticking, and plugging, keep coal and ores in bins, hoppers and chutes free-flowing.

SYNTRON Bin Vibrators keep coal and ores, fine, lump or run-of-mine flowing freely to process equipment, efficiently and effectively, without waste of labor or equipment damage. They work on an electromagnetic principle that produces 3600 powerful vibrations per minute, enough to keep the most stubborn materials moving freely. Amplitude or power of vibration is instantly adjustable to the characteristics of the material. Simplicity of design eliminating mechanical wearing parts assures long, dependable service with low maintenance. There are no expensive parts to replace—never need lubrication.

SYNTRON Bin Vibrators provide a positive, safe method of keeping materials flowing freely. If you have a problem of coal and ore build-up, sticking, plugging in bins, hoppers, and chutes think of dependable, versatile SYNTRON Bin Vibrators. Available in sizes for every operation, large or small.

Write for free information

SYNTRON COMPANY

554 Lexington Ave. Homer City, Pa.

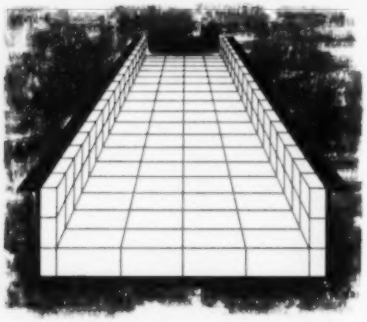
Other SYNTRON Equipment of proven dependable Quality

VIBRATING SCREENS

COUNTER BALANCED VIBRATING CONVEYORS

MECHANICAL SHAFT SEALS

NEW LONG LIFE
FOR
CHUTE LININGS



and SURGE BINS
with
ARLCITE
WEAR BLOCKS

High-density Arlcite blocks today are extending the service life of chute and bin linings as much as six times that of hardened steel alloy plates. Extraordinary resistance to abrasion makes this high alumina ceramic the economical choice for lining surfaces exposed to abrasive materials. The patented tongue-and-groove construction insures a tightly-keyed lining which will remain in place under the most severe operating conditions.

Arlcite wear blocks are of the same tough-bond composition as Arlcite high-density mill linings and grinding media supplied to industry since 1936. Write for additional details and new Ceramic Bulletin 1259-P.

PORCELAIN DIVISION
FERRO CORPORATION
East Liverpool, Ohio

Obituaries

Charles E. Tonry

An Appreciation By The
Source Material Procurement Div.

Charles E. Tonry (Member 1943), director of the Source Material Procurement Div. of the Atomic Energy Commission's Grand Junction Operations Office, died suddenly of a heart attack on Dec. 21, 1958. He was a veteran of 32 years in the mining and mineral industry.

Mr. Tonry was born May 3, 1903, in Boston and was graduated from the Massachusetts Inst. of Technology with a mining degree in 1926. After graduation he worked as a mine engineer for the Smuggler Union Mining Co. of Telluride, Colo. Mr. Tonry then worked in Mexico and New York.

Mr. Tonry returned to Colorado in May 1932, where he was in charge of building and operating a small mill to process tailings from the mills in the Telluride area.

In 1934 he reopened several old workings in the Telluride area. This work and the subsequent report served as a basis for the Treasury Tunnel development of Idarado Mining Co.

In 1935 he became mill superintendent for Cripple Creek Mining and Milling Co. at Cripple Creek, Colo. From 1937 to 1940 he was mill superintendent for Desert Silver Inc. at Silver Peak, Nev. Mr. Tonry joined Southwestern Engineering Co. of Los Angeles in 1940 and progressed in that organization as an engineer, chief surveyor, chief designer, project engineer, and chief engineer.

After a brief retirement which ended in 1946 he started work with Harshaw Chemical Co. at El Segundo, Calif., and in 1949 he returned to Southwestern Engineering Co. where he became engineering assistant to the president.

In 1951 he joined the U. S. Bureau of Mines at the Rifle, Colo. Oil Shale demonstration plant, as chief of the cost estimating unit and later became chief of planning and evaluation section.

Mr. Tonry joined the AEC in 1954 as director of the Processing Division. In 1957 the Grand Junction Operations Office was reorganized and the name of the division was changed to Source Material Procurement. In this position he had a very important part in negotiation of uranium concentrate procurement contracts with producers in the western U. S. He was also in charge of administering contracts with the 24 uranium mills currently in operation.

Mr. Tonry was well known and respected in the mining and milling industry in general and in the uranium industry in particular. His loss will be deeply felt by those of us who had the good fortune to work with him.

He is survived by his wife, Romilda, and a son, Robert.

Howard Glen Wilcox

An Appreciation By
Leo H. Saarela

The tragic death of Howard Glen Wilcox (Member 1936) occurred in a military airplane crash at Anchorage on Sept. 9, 1958. Mr. Wilcox, known affectionately by his many friends and former students as Dean, was born in Seattle on Sept. 25, 1894. His education was disrupted by World War I and he attended Officers Training School in the Field Artillery in 1918. He received his B.S. from the University of Washington in 1920, M.S. in 1931, and E.M. in 1935, and during his graduate years he worked in various mines in Washington and in Alaska in the Willow Creek and Kennecott districts.

In 1935 he was appointed supervisor of mining extension and later dean of the School of Mines at the University of Alaska, a position which he held with distinction until 1948. During those years he worked actively throughout the mining camps of the Territory as an able and respected consultant, making many examinations for the industry and writing a number of authoritative articles on Alaskan mining. His interests were many, his influence on his students and his work for the University were most effective. From 1948 until 1953 he served as an engineer for the Reconstruction Finance Corp. and was later employed as a construction engineer especially versed in Arctic conditions for the Air Force. He was on his way to a remote site at the time of his death.

Dean Wilcox was blessed with warm human qualities and his interests and counsel to his many friends and associates will be missed. He leaves a widow, Mrs. Helen U. Wilcox of Anchorage; a son, Donald, of Anchorage; a son James of Seoul, Korea; a daughter, Mrs. Dennis Fenno of Anchorage, and twelve grandchildren.

Clarence O. Stee (Member 1916) died in Williamsville, N. Y., on Dec. 28, 1958. Born in North Dakota in 1886, he was educated at the College of Mines, University of North Dakota, receiving an E.M. degree. He went to Canada in 1912 to join Bithulitic & Contracting Co. in Winnipeg, Man. For several years he was in Peru with Cerro de Pasco Copper Corp., acting as superintendent of the Cerro mining department for two years. He went to Butte, Mont., and worked for Butte

& Superior and Anaconda Cos., then was manager of Idawa Gold Mining Co. in Boise, Idaho. He journeyed again, this time to Mexico, then returned to Canada as manager, Siscoe Gold Mines Ltd., Siscoe, Que. where he took up permanent residence in 1930.

Howard T. Walsh (Member 1915) died on Oct. 10, 1958. He was born in Newburgh, N. Y., in 1878 and received a B.S. degree from Worcester Polytechnic Inst. He joined Sullivan Machinery Co. in 1900 in Chicago, testing and selling mining machinery. At the time of his election to AIME he had been with the firm for 17 years.

Bleecker L. Wheeler (Member 1926) passed away in Chicago on Jan. 4, 1958. He was born in 1883 and received an E.M. degree at Columbia University School of Mines in 1905. He became engaged in mineral property examination work and served as mineral examiner for ten years with the Department of the Interior in the U. S. Court. Then he joined the staff of Consolidation Coal Co. and later became valuation engineer and chief engineer of the Amortization Section of the U. S. Bureau of Internal Revenue. He served for 28 years as senior mining engineer for Ford, Bacon & Davis Inc., working on investigations of industrial properties in connection with financing, mergers, depreciation procedure and valuations. He was continually interested in AIME affairs and served on the committee on *Methods of Valuing Coal Properties*.

Roy E. O'Brien

Memorial Resolution Prepared by Andrew Fletcher and H. DeWitt Smith

WHEREAS, Roy E. O'Brien of Salt Lake City has served the AIME capably and admirably as Western Secretary of the Mining Branch from 1950 to 1952, and as Field Secretary from 1952 until his death on January 9, 1959; and

WHEREAS, he has demonstrated outstanding ability, energy, a penetrating understanding of the mining engineering profession, and by his practical experience, exemplary character, warmth, friendliness, and devotion to the membership of AIME, has contributed to its growth and importance;

BE IT RESOLVED, that the Board of Directors express their deep sense of loss on the death of Roy E. O'Brien and extend their sincere sympathy to his family; and

RESOLVED FURTHER, that this Resolution be recorded in the Minutes of the meeting, and that a copy be sent to Mrs. O'Brien.

February 15, 1959

George W. Paymal (Legion of Honor Member 1904) died Mar. 30, 1958. Born in Nevada in 1875, he worked on his own for nearly ten years doing mill tailings of one to three thousand tonnages. With his own lab he worked out suitable methods, then reconditioned abandoned plants for his one-man operation. He also did exploration and prospecting in Utah, Arizona, and California.

Warren M. Peterson (Member 1956) died on Aug. 19, 1958. He was born in Pittsburgh, Kan., in 1924 and went to Bradley Polytechnic Inst., Kansas State Teachers College, and the Missouri School of Mines and Metallurgy where he received a B.S. in mining. In 1948 he was an engineer for Sinclair Coal Co. In 1951 he became pit boss for Huntsville Sinclair Coal Co. Other positions included assistant superintendent and underground mine foreman, for Victorville Lime Rock Co. and Riverside Ce-

Still Available • • •

AIME Transactions Volumes

MINING

The following AIME Transactions of the Mining Branch and Society of Mining Engineers are still available:

1949 Volume 184
1954 Volume 199
1955 Volume 202
1956 Volume 205
1957 Volume 208

Price per volume: $4.90 for members; $7.00 nonmembers

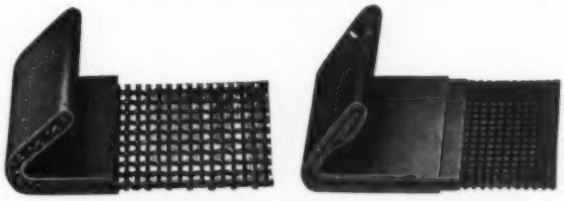
(An additional charge of 50¢ is made for each book mailed outside the United States to nonmembers.)

Orders should be sent to:

Business Office

American Institute of Mining, Metallurgical, and Petroleum Engineers
29 West 39th Street
New York 18, New York

Tyler Screen Sections for All Makes of Screening Machines!



Screen sections of Tyler Woven Wire are fabricated for all makes of vibrating screens in any mesh or metal. They are made up with hook-strip or bent-edge construction to suit the machine on which they are to be used.

Tyler rugged, accurately-applied hook-strips make possible stretching and maintaining the screens at drum-head tension, which is essential for successful screening and long screen life.

THE W. S. TYLER COMPANY
CLEVELAND 14, OHIO
Manufacturers of Woven Wire Screens and Screening Machinery
Canadian Plant—St. Catharines, Ontario, Canada

Henry Krumb

Memorial Resolution Prepared by Henry DeWitt Smith

WHEREAS, with the death of Henry Krumb on December 27, 1958, this country has lost one of its most illustrious engineers, and the Institute one of its stoutest supporters, through adverse times and good, and

WHEREAS, during his 53 years of membership, he served as Vice President during the critical period from 1928 to 1942, and was awarded Honorary Membership in the Institute in 1939, and

WHEREAS, during his lifetime he concentrated as consulting mining engineer on the development of porphry copper mines in the western U. S. and South America, combining engineering skill with financial acumen to the advantage of the copper industry of North and South America, and

WHEREAS, he was an inspiration to his fellow engineers and an example to the younger generation in his professional conduct and modesty, and through scholarships, encouraged them to become mining engineers;

THEREFORE, BE IT RESOLVED, that the American Institute of Mining, Metallurgical, and Petroleum Engineers record its great sorrow over the loss of this distinguished member of our profession, and

BE IT FURTHER RESOLVED, that this Resolution be spread upon the Minutes of this meeting, and a copy sent to Mrs. Krumb.

February 15, 1959

ment Co. He was employed at the time of his death by Jackson Ready-Mix Concrete Co. at Jackson, Miss.

Herman A. Prosser (Legion of Honor Member 1897), retired mining engineer and former vice president of the American Smelting and Refining Co., died on Nov. 22, 1958. A native of New York, Mr. Prosser graduated from Columbia University in 1896.

Otto Ruhl (Member 1946) was born and raised in Missouri and died there on June 21, 1958, after a varied career in mining journalism and field exploration. He graduated from Drury College in 1904 and began as a field reporter for the Lead & Zinc News in St. Louis. For several years he was an editor in Joplin, and mine surveyor for the Missouri State Geological Survey. Many of his articles have been published in *Mining World* and other journals. He also organized the General Engineering & Equipment Co. and was a mining consultant for the U. S. Bureau of Mines.

Joseph L. Shugert (Member 1921), ventilation engineer for Anaconda Co., died in a mining accident Mar. 21, 1958. He was making an exploratory trip through the Badger mine in Butte, Mont. Mr. Shugert had received a B.S. degree from Washington State College and had been employed by Anaconda since graduation.

Frank H. Skeels (Member 1915) died on Nov. 20, 1958. He graduated from Washington State College of Mines in 1911 with a B.S. degree. His many mining jobs included positions as superintendent of the Dobler mine and the August mine; manager of the Granite Doorman mine in British Columbia; operating partner at the Beartop mine in Idaho; and instructor at the underground mining school, Vocational Education Dept. of the State of Idaho. He was also field engineer for the Idaho State Bureau of Mines & Geology, and manager of several other enterprises.

William H. Stewart (Member 1920) passed away Aug. 8, 1958. A native of Indiana, he had many engineering jobs in neighboring states, with the National Engineering Co., Columbus, Ohio; the Warren Engineering Co.; the Western Brick Co., Danville, Ill.; and Central Indiana Coal Co. where he was general superintendent and engineer.

Martin J. Heller (Legion of Honor Member 1896) died in New York on Oct. 17, 1958. He was organizer of the San Luis, Andaray, Chabuca, and Capitana gold mine companies in Peru, which were operated jointly by the Cia Administradora de Minas, South America, and Leon J. Rosenshine. Also he was a director of Cia Minera Los Angeles of Honduras, a lead and zinc mining company. He had been born in San Francisco and attended the University of California.

Graham P. Crutchfield (Member 1928) died on June 10, 1958. He had served as superintendent of Roeser & Pendleton Inc. when they developed the Cook Field in 1926. This Texan field became one of the largest independent producing companies of the area. He also headed the conservation program. Mr. Crutchfield continued as vice president when the firm was purchased by Marshall R. Young. He was born in Navasota, Texas, attended Texas Agricultural and Mechanical College, and died in Albany, Texas.

Eldridge D. Flournoy (Member 1953), material handling equipment specialist, has passed away. He was born in Chelsea, Okla., in 1898, attended public schools and resided in El Paso, Texas. He was owner of the E. D. Flournoy Co. with offices in El Paso, Phoenix, Lubbock, and Albuquerque.

H. W. Hentschel (Member 1940) died on Oct. 20, 1958. Born in Leipzig, Germany, in 1900, he received his degree in mining engineering from the School of Mines, Freiberg, Saxony, Germany. In 1926 he came to the U. S. and was associated with the Lehigh Portland Cement Co. He went to Alaska for Kennecott Copper Corp. and then became consulting mining engineer for the E. J. Lavino and Co. in Philadelphia.

William D. Hubler (Member 1942) died in Ottawa, Canada, on Sept. 20, 1958. He was born in Durango, Colo. and attended Tri State College in Indiana, receiving a B.S. in chemical engineering. Since graduation he had been active in mining and metallurgy in the U. S., Vene-

For Classifying Sand Feeds into Multiple Sizes

The CONCENCO® CPC Classifier sorts your sand fraction into sharply defined sizes . . . up to 10 or more . . . one for each cell in the classifier. Operating by hydraulic water only, and with no moving parts, the CONCENCO Classifier is economical, fast and accurate. Action is visible, water adjustment simple and maintenance costs are negligible. Send for full information.

THE DEISTER CONCENTRATOR CO., INC.

The Original Deister Company, Established 1906

923 Glasgow Avenue — Fort Wayne 3, Indiana

zuela, and Greece before coming to Canada in 1954. He was associated with Quebec Metallurgical Industries in charge of the exploration of Bugaboo Placers in British Columbia and in the development of a process for columbium and tantalum metal.

James E. Jewell (Member 1943), geologist, died in Bonne Terre, Mo., on July 9, 1958. He had served the St. Joseph Lead Co. in various capacities since 1925 and for the past eight years had been general prospecting superintendent in charge of diamond drill operations in southeast Missouri.

Fred T. Mathews (Member 1952) died in Salt Lake City. Mr. Mathews was owner of Mathews Silica Co. and vice president of H M & S Milling Co. Born in 1908 in Utah, he went to the University of Utah. He was in the engineering department of American Smelting & Refining Co. and has been self-employed in several enterprises.

Membership

Proposed for Membership
Society of Mining Engineers of AIME

Total AIME membership on Feb. 28, 1959, was 30,889; in addition 3,974 Student Members were enrolled.

ADMISSIONS COMMITTEE

A. E. Weissenborn, Chairman; Frank A. Ayer, Vice Chairman; R. T. Lassiter, Charles H. Lambur, Alfred D. Rood, William J. Rude, L. P. Warriner.

The Institute desires to extend its privileges to every person to whom it can be of service, but does not desire as members persons who are unqualified. Institute members are urged to review this list as soon as possible and immediately to inform the Secretary's office if names of people are found who are known to be unqualified for AIME membership.

Members

Walter T. Ashlock, Albuquerque, N. M.
Theodore J. Barker, Chisholm, Minn.
Margaret F. Boos, Denver
Herman H. Boschen, New York
James E. Brown, Jr., Birmingham
Tom T. Brown, Duluth
Alain Bullet, Bou-Beker, Morocco
Alexander D. Burton, Vancouver, B. C., Canada
Felipe Camelo G., Monterrey, N. L., Mexico
Thomas D. Campbell, Osburn, Idaho
William B. Clark, Sacramento, Calif.
Daniel Chique, Bou-Beker, Morocco
James Crosby, Leadville, Colo.
Dirk den Baars, Tucson, Ariz.
Mauri E. Erkkila, Chisholm, Minn.
Percival H. Fitzgerald, Charleston, W. Va.
Delos E. Flint, New Orleans
Richard H. Franklin, Laguna Beach, Calif.
Otis J. Gibson, Ducktown, Tenn.
Walter L. Gonnason, Everett, Wash.
Walter R. Gould, Grants, N. M.
James A. Graham, Ferndale, Mich.
Inocencio O. Hidalgo, Baguio City, Philippines
Raymond C. Johnson, Payson, Utah
V. Kalyanasundaram, New Delhi, India
W. Grant Kilbourne, Pocatello, Idaho
Kurt R. Kuehlthau, Iron River, Mich.
Lewis H. Lehman, Glen Ellyn, Ill.
Harold D. Letts, Zelienople, Pa.
Robert A. Limons, Bethlehem, Pa.
Joseph S. Luckett, El Paso, Texas
William B. Magyar, Niagara Falls, Ont., Canada
William R. Mahoney, El Paso, Texas
James W. Miller, Charleston, W. Va.
Donald K. Montez, Oakland, Calif.
Preston H. Mulcahy, Atherton, Calif.
Lemoyne S. Olson, Ironton, Minn.
John T. O'Rourke, New York
John A. Pigott, Copper Cliff, Ont., Canada
William T. Reed, Jr., Downieville, Calif.
Marvin B. Seldin, Battle Mountain, Nev.
Robert Semrad, Jaltipan, Vera, Mexico
Wesley L. Shadduck, Idria, Calif.
John A. Stachura, Vincennes, Ind.
George W. Thompson, Alhambra, Calif.
Donald C. Vernon, Batchelor, Australia
Francisco O. Viniegra, Mexico City

Associate Members

Cornelius E. Berthold, Trona, Calif.
Robert J. Clark, Clearwater, Fla.
Edwin E. Cockrell, Cleveland, Ohio
Luis J. Creel, Mexico City
William R. DeVilliers, Albuquerque, N. M.
Robert S. King, Golden, Colo.
Apostoles Manchuris M., Lima, Peru
Federico H. Rodriquez, Mexico City
Kenneth A. Tallmadge, Kellogg, Idaho
Russell K. Wasmann, San Francisco
Morris S. Wood, Ajo, Ariz.
Warren E. Wright, Grand Junction, Colo.

Junior Members

Burdette D. Bair, Berkeley, Calif.
Pierre Brosseau, Jr., Montreal
John A. Casey, Cleveland
Robert E. Mauney, Shelby, N. C.
John W. Mossop, Thetford Mines, Que., Canada
Ben C. Trethewey, Iron Mountain, Mich.
Heinz F. Wesemann, Henkenbergstr, Germany

CHANGE OF STATUS

Associate to Member

Herman L. Bauer, Jr., Ruth, Nev.
Irving M. Craig, Martinsburg, W. Va.
Paul K. Edwards, Monteagle, Tenn.
Glen E. Hanson, Canon City, Colo.
Edson K. Hartzell, Denver, Colo.
Harold D. Hess, Albany, Ore.
Richard W. Lewis, Jr., Washington, D. C.
Clark H. McNaughton, Jr., Austinville, Va.
Charles R. Pace, Jr., Green Cove Springs, Fla.
Richard L. Philippone, Grand Junction, Colo.
Joseph S. Quinn, St. Louis, Mo.
Alan J. Robinson, Tororo, Uganda, British E. Africa
Robert N. Saunders, Brewster, Fla.
Jerry F. Whalen, Boise, Idaho

Junior to Member

Robert H. Ashlock, Reno, Nev.
Peter Beaumont, London, England
Alan F. Keenan, Dover, N. J.

REINSTATEMENTS

Member

Richard J. Anderson, Columbus, Ohio
Raymundo C. Llamas, Mexico City

Associate

Robert H. Pearson, Denver

REINSTATEMENT—CHANGE OF STATUS

Student to Member

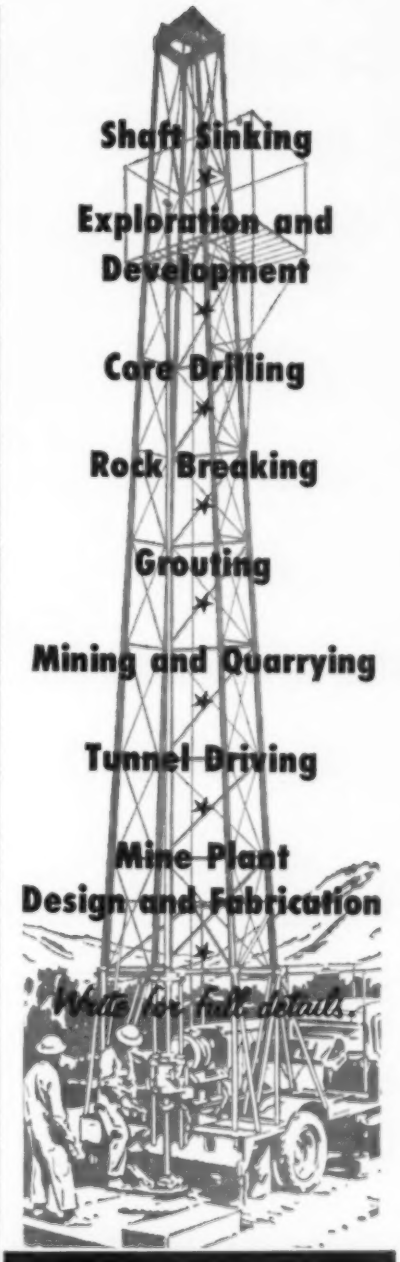
Jorge C. Nieto, Mexico City
James C. Tiffany, Fairplay, Colo.

Student to Junior

Francis D. Hake, Virginia, Minn.

Necrology

Date Elected	Name	Date of Death
1940	C. L. Babin	Unknown
1949	G. Gerald Bauer	Unknown
1947	Eric E. G. Boyd	Sept. 9, 1958
1898	Victor B. Buck Legion of Honor	Unknown
1952	P. Thomas Carter	Unknown
1948	Ben B. Chomiak	1958
1949	Agostino G. Coda	Nov. 21, 1958
1956	James M. Cuneo	Jan. 28, 1959
1940	John H. Eggers	Jan. 9, 1959
1913	M. J. Elsing	Feb. 27, 1959
1939	E. Gordon Gray	Unknown
1903	S. M. Greenidge Legion of Honor	Jan. 2, 1959
1928	Norman B. Holter	Feb. 8, 1957
1956	F. M. Jackson	Dec. 11, 1958
1917	John Knox	Unknown
1946	Keith Kunze	Dec. 29, 1958
1941	P. B. Leavenworth	Dec. 31, 1958
1936	R. W. McIlvain, Jr.	Feb. 16, 1959
1925	James E. Moore	Dec. 7, 1958
1951	N. W. Nichols	Unknown
1925	Joseph A. Norden	Jan. 7, 1959
1918	Louis W. Olson	December 1958
1946	E. K. Pryor	June 1, 1958
1952	Donald H. Randall	Feb. 22, 1959
1943	John W. Sheedy	Jan. 16, 1959
1917	A. S. Shoffstall	Feb. 23, 1959
1957	Harold R. Swingle	Jan. 31, 1959
1902	Howard H. Utley Legion of Honor	Feb. 15, 1959
1953	E. Stuart Ward	Feb. 27, 1958
1954	W. H. Watters	Dec. 6, 1958
1914	Sidney L. Wise	Feb. 28, 1959



Boyles Bros. DRILLING COMPANY

GENERAL OFFICES:
Salt Lake City, Utah — HUnter 7-7595

BRANCHES:
Phoenix, Arizona — CRestwood 4-5331
Sacramento, California — IVanhoe 3-5221
Denver, Colorado — ALpine 5-9244
Boise, Idaho — 3-7152
Reno, Nevada — FAirview 9-0732
Spokane, Washington — WAlnut 4-2614
Alaska — Contact Salt Lake City Office

PROFESSIONAL SERVICES

Listing Instructions

Space limited to AIME members or to companies that have at least one member on their staffs. One inch, $50 per year; half inch, $30 per year, payable in advance.

Alabama

COWIN & COMPANY, INC.
Mining Engineers and Contractors
Shaft & Slope Sinking • Mine Development
Mine Plant Construction
1-18th Street SW,
Birmingham, Ala. **Phone 56-5566**

KIRK & COWIN, INC.
RALPH E. KIRK PERCY G. COWIN
Mining Consultants and Engineers
One 18th St., S. W., Birmingham 11, Ala.
Phone: STate 6-5566

Alaska

ALASKA MINERAL CONSULTANTS
P.O. Box 3686 Phone 69867
(airmail)
Anchorage, Alaska

WILLIAM A. O'NEILL
Registered
Consulting Mining Engineer-Geologist
Exploration-Valuation-Management
Anchorage, Alaska
Phone 47671 **P.O. Box 2000**

Arizona

THEODORE A. DODGE
Consulting Mining Geologist
635 North Third Ave. Tucson, Arizona

HEINRICHS GEOEXPLORATION CO.
Mining Oil, Water Consultants & Contractors
MOBILE MAGNETOMETER SURVEYS
Geophysics Geology Geochem & Evaluations
Box 5071, Tucson, Ariz. PH: MA 2-4202

JAMES A. HOAGLAND
Consulting Mining Geologist
635 North Third Ave. Tucson, Arizona

THORP D. SAWYER
Consulting Engineer
Registered in Mining and Civil
4828 East Grant Road
Tel. EAst 6-5336 Tucson, Arizona

CHARLES P. SEEL
Mining Geology
Examinations in Mexico
635 North Third Ave. Tucson, Ariz.

STILL & STILL
Consulting Mining Engineers and Geologists
24 Union Block — Phone 658
P.O. Box 1512
Prescott, Arizona

VOUGHT & CLOETER, LTD.
Diamond Core Drilling Contractors
(Specialists in wireline)
2000 S. Freeway Box 5751
Tucson, Arizona MA 4-5452

Arkansas

RAPHAEL G. KAZMANN
Consulting Ground-Water Engineer
Stuttgart, Arkansas

California

FAIRCHILD AERIAL SURVEYS, INC.
Airborne Magnetometer & Gradiometer Surveys, Topographic Mapping, Aerial Photography, and Photographic Mosaics for Mining Exploration.
224 E. 11th St. Los Angeles
30 Rockefeller Plaza New York

FRANCIS H. FREDERICK
Consulting Mining Geologist
690 Market Street
San Francisco 4, California
Telephone: Sutter 1-1562

ABBOT A. HANKS, Inc.
ASSAYERS-CHEMISTS
Shippers Representatives
624 Sacramento Street
SAN FRANCISCO

WARREN L. HOWES
Consultant
Mining & Metallurgical Plants
Research, design, construction, operations
Project Management
Estimates—Appraisals
1305 Hillview Dr., Menlo Park, Calif.
Tel. DAvenport 5-7752

CARLTON D. HULIN
Mining Geology
7 Ardilla Road Orinda, California

JACOBS ASSOCIATES
Consulting Construction Engineers
Specialists in tunnel and shaft work — Estimates — Methods Analyses — Engineering Geology — Designers of hoisting, haulage, materials handling and reduction plants.
503 Market Street, San Francisco 5, Calif.

KELLOGG EXPLORATION COMPANY
Geologists-Geophysicists
Air, Ground Surveys and Interpretation
3301 No. Marengo, Altadena, Calif.
Sycamore 4-1973

KELLOGG KREBS
Mineral Dressing Consultant
564 Market St., San Francisco 4, Calif.

CLAYTON T. McNEIL, E. M.
Consulting Mining Engineer
822 Bank of America Bldg.
Tel. GArfield 1-2948
SAN FRANCISCO 4, CALIFORNIA

ASSAYS—Complete, accurate, guaranteed. Highest quality spectrographic. Only $5 per sample.
REED ENGINEERING
620-AB So. Inglewood Ave.
Inglewood 1, Calif.

Colorado

BALL ASSOCIATES
Oil, Gas and Minerals Consultants
Douglas Ball S. Power Warren
Offices
C. A. Johnson Bldg. Denver, Colo. ALpine 5-4878
1025 Vermont Ave. Washington, D. C. STerling 3-1929

O. W. WALVOORD CO.
Mill-Design and Construction
401 High St. Denver 3, Colo.

Connecticut

JOHN F. MYERS
Consulting Beneficiation Engineer
2 Putnam Hill
Greenwich, Conn.

GODFREY B. WALKER
Metallurgical Consultant
Mineral Dressing & Extractive Metallurgy
Heavy Media a Specialty
33 Bellwood Road, Old Greenwich, Conn.

District of Columbia

JOHN D. MORGAN, JR., E. M., PH. D.
Consultant
Business and Defense Problems in Metals, Minerals, and Fuels
1001 Connecticut Ave., N.W.
Washington 6, D. C.
ME 8-1681

CLOYD M. SMITH
Mining Engineer
Mine Examinations
Ventilation Surveys
Munsey Building Washington 4, D.C.

APPRAISALS • CONSTRUCTION • GEOLOGISTS
ASSAYERS • CONSULTING • GEOPHYSICISTS
CHEMIST • DRILLING • MANAGEMENT
METALLURGICAL • REPORTS • VALUATIONS

Florida

HARRY B. CANNON ASSOCIATES
Geologists — Engineers
Exploration Ore Dressing
Specialists in Heavy Minerals
P.O. Box 2432 Lakeland, Florida

ALLEN T. COLE and ASSOCIATES
Consultants — Industrial Minerals
Phosphate, Barite, Heavy Minerals, Industrial Sands
2815 Cleveland Heights Blvd.
Lakeland, Florida
MUtual 9-9351 MUtual 3-9033

Frank M. Murphy & Associates, Inc.
DESIGN & CONSTRUCTION ENGINEERS
Specializing in Material Handling Mining Mineral Beneficiation & Chemical Processing
Wesley M. Houston John C. Yost
J. D. Roulerson, Jr.
Box 271 Bartow, Fla.

Georgia

BLANDFORD C. BURGESS
Registered Professional Engineer
Mining Consultant
Monticello, Georgia

Idaho

6526 Holiday Drive Phone
Boise, Idaho 4-1925
WARREN R. WAGNER
Geologist
Serving the Mining, Chemical and Construction Industries

Illinois

ALLEN & GARCIA COMPANY
47 Years' Service to the Coal and Salt Industries as Consultants, Constructing Engineers and Managers
Authoritative Reports and Appraisals
332 S. MICHIGAN AVE., CHICAGO
120 WALL ST., NEW YORK CITY

JOHN F. MEISSNER ENGINEERS, INC.
Consulting Engineers
Conveyor Systems Storage Methods
Crushing Plants Ship Loading Docks
Materials Handling and Processing Plants
308 W. Washington St. Chicago 6, Ill.

PAUL WEIR COMPANY
Mining Engineers and Geologists
Consultants and Managers
Design and Construction
20 No. Wacker Drive Chicago 6, Ill.

Indiana

DIAMOND CORE DRILLING BY CONTRACT
and world's largest manufacturer
Core and grout hole drilling in coal, metal, and non-metallic deposits, both surface and underground.
JOY MANUFACTURING CO.
Contract Core Drill Division
Michigan City, Indiana

Kansas

DAVID LeCOUNT EVANS
Consultant
Mining Geology Petroleum Geology
314 Brown Bldg. Wichita, Kansas
Tel.: AMherst 2-8954 or MUrray 3-6437

Kentucky

JAMES M. DANIEL — JAMES J. LEWIS AND ASSOCIATES
Civil and Mining Engineering Consultants
United States and Foreign
860 Porter Place Lexington, Ky.

Maine

G. F. COOPE
Mining Engineer
BLUE HILL, MAINE

Massachusetts

RAYMOND B. LADOO
Consulting Engineer—Industrial Minerals
Deposit Location, Exploration, Process Design, Marketing, Economics, Percentage Depletion.
42 Huntington Road Newton 58, Mass.
Phone: (Boston) LAsell 7-1471

H. L. TALBOT
Consulting Metallurgical Engineer
Extraction and Refining of Base Metals
Specializing in Cobalt and Copper
Room 911, 209 Washington Street
Boston 8, Mass.

Minnesota

THERON G. GEROW
MINING CONSULTANT AND ENGINEER
3033 Excelsior Blvd.
Minneapolis 16, Minn.
Telephone: Walnut 2-8828

Continued on Page 558

DIRECTORY OF PROFESSIONAL SERVICES

Alaska Mineral Consultants ..... Alaska
Allen & Garcia Company ..... Illinois
Anderson, E. C. ..... New Mexico
Ball Associates ..... Colorado
Barr, James A. ..... Tennessee
Bateman, J. D. ..... Canada
B. B. R. Drilling Co. ..... Ohio
Behre Dolbear & Company ..... New York
Booth Co., Inc. ..... Utah
Burgess, Blandford C. ..... Georgia
Cannon Associates, Harry B. ..... Florida
Centennial Development Co. ..... Utah
Cole and Associates, Allen T. ..... Florida
Coope, G. F. ..... Maine
Cowin & Company, Inc. ..... Alabama
Daniel, James M. ..... Kentucky
Dodge, Theodore A. ..... Arizona
Eavenson, Auchmuty & Greenwald ..... Pennsylvania
Evans, David LeCount ..... Kansas
Fairchild Aerial Surveys, Inc. ..... California
Frederick, Francis H. ..... California
Geraghty, Miller & Hickok ..... New York
Gerow, Theron G. ..... Illinois
Graff Engineering Company ..... Pennsylvania
Hanks, Inc., Abbot A. ..... California
Hanson, Frederick W. ..... California
Heinrichs Geoexploration Company ..... Arizona
Hoagland, James A. ..... Arizona
Howes, Warren L. ..... California
Hulin, Carlton D. ..... California
Ingersoll, Guy E. ..... Texas
Irving, I. G. ..... Washington
Jacobs Associates ..... California
Jones, Philip L. ..... Missouri
Joy Manufacturing Co. ..... Indiana
Kazmann, Raphael G. ..... Arkansas
Keegel, C. P. ..... Nevada
Kellogg Exploration Company ..... California
Kellogg Krebs ..... California
Kirk & Cowin ..... Alabama
Ladoo, Raymond B. ..... Massachusetts
Ledoux & Company ..... New Jersey
Leggette, Brashears & Graham ..... New York
Leland, George R. ..... New Mexico
Longyear Company, E. J. ..... Minnesota
Loofbourow, R. L. ..... Minnesota
Lottridge-Thomas & Associates ..... Utah
Mathews Engineering Co., Abe W. ..... Minnesota
Mayo, Robert S. ..... Pennsylvania
McClintock, R. S. ..... Washington
McNeil, Clayton T. ..... California
Meissner Engineers, Inc., John F. ..... Illinois
Miller, Inc., Arnold H. ..... New York
Morgan, Jr., John D. ..... District of Columbia
Morrow, J. B. ..... Pennsylvania
Mott Core Drilling Co. ..... West Virginia
Murphy & Associates, Inc., Frank M. ..... Florida
Myers, John F. ..... Connecticut
O'Donnell & Schmidt ..... New York
O'Neill, William A. ..... Alaska
Pearse, H. A. ..... New York
Pennsylvania Drilling Company ..... Pennsylvania
Peugnet, Amedee A. ..... Missouri
Pickering, H. M. ..... Minnesota
Pierce, Roger V. ..... Utah
Pitkin, Inc., Lucius ..... New York
Reed Engineering ..... California
Sawyer, Thorp D. ..... Arizona
Schoenike, Howard G. ..... Texas
Seel, Charles P. ..... Arizona
Sharpstone, David C. ..... So. Rhodesia
Shedwick, Jr., William J. ..... Mexico
Shenon and Full ..... Utah
Smerchanski, M. G. ..... Canada
Smith, Lloyd M. ..... District of Columbia
Sprague & Henwood, Inc. ..... Pennsylvania
Still & Still ..... Arizona
Talbot, H. L. ..... Massachusetts
Thoenen, J. R. ..... Tennessee
Thomas, Conrad Ward ..... Texas
Thompson & Little ..... Virginia
Torkelson Co., F. C. ..... Utah
Vought & Cloeter Ltd. ..... Arizona
Wagner, Warren R. ..... Idaho
Walker, Godfrey B. ..... Connecticut
Walvoord Co., O. W. ..... Colorado
Weir Company, Paul ..... Illinois
Wolf, Harry J. ..... New York
Woomer & Associates, J. W. ..... Pennsylvania
Wysor, D. C. ..... New York

See pages 558 and 559

PROFESSIONAL SERVICES CONTINUED

For other items,

see

pages 556 and 557

E. J. LONGYEAR CO.
Geological and Mining Consultants
Photogeology
76 South 8th Street.....Minneapolis, Minn.
Graybar Bldg.....New York 17, N. Y.
Colorado Bldg.....Denver 2, Colo.
Shoreham Bldg.....Wash. 5, D. C.
77 York Street.....Toronto, Ont.
129 Ave. de Champs-Elysees...Paris, France
Zeekant 35.....The Hague, Holland

R. L. LOOFBOUROW **Min. Engr.**
Site Testing — Plans — Estimates
Underground Construction — Mining
Mine Water Problems
4032 Queen Ave. So. Minneapolis 10, Minn.

ABE W. MATHEWS ENGINEERING CO.
Iron Ore Concentration Plants
Materials Handling Systems
Design and/or Construction
Hibbing Minnesota

H. M. PICKERING
Registered Professional Engineer
Mining Consultant
Truck Haulage & Crushing Plants
302 E. 22nd, Hibbing, Minn. AM 3-5153

Missouri

PHILIP L. JONES
Consultant
Mineral Economics & Mineral Dressing
Heavy Media Specialist
405 Miners Bank Bldg. Joplin, Mo.
Tel. MAyfair 3-7161

AMEDEE A. PEUGNET
CONSULTING MINING ENGINEER
Telephone MAIN 1-1431
705 Chestnut St. St. Louis 1, Mo.

Nevada

C. P. KEEGEL
Mining and Metallurgical Engineer
Administration Appraisal
1721 So. 14th St., Las Vegas, Nevada
Telephone DUdley 4-6981

New Jersey

LEDOUX & COMPANY
Chemists Assayers Spectroscopists
SHIPPERS REPRESENTATIVES
Mine Examination Analyses
359 Alfred Ave. Teaneck, New Jersey

New Mexico

EUGENE CARTER ANDERSON
Mining Engineer—Geologist
Examination—Development—Production
Socorro, New Mexico
P. O. Box 642 Tel. 159

GEORGE R. LELAND
Registered by written examination
Mining Engineer & Geologist
U.S.A. and Latin America
P.O. Box 4146 Albuquerque, N.M.

New York

BEHRE DOLBEAR & COMPANY, INC.
Geological, Mining and Metallurgical Consultants
11 Broadway New York 4, N. Y.

GERAGHTY, MILLER & HICKOK
Consulting Ground-Water Geologists
Evaluation of Ground-Water Supplies
Recommendations for the Solution of Ground-Water Problems
110 East 42nd St. New York 17, N. Y.

LEGGETTE, BRASHEARS & GRAHAM
Consulting Ground-Water Geologists
Water Supply Salt Water Problems
Dewatering Investigations
Recharging Reports
551 Fifth Avenue, New York 17, N. Y.

ARNOLD H. MILLER INC.
Consulting Engineer
Mine, Mill and Industrial Investigations
Improvement Design and Recommendations
Cable: "ALMIL" Tel. Cortlandt 7-0635
120 Broadway New York 5, N. Y.

O'DONNELL & SCHMIDT
Mining Consultants
165 Broadway Tel. BArclay 7-6960
New York 6, N. Y. Cables: EXAMIMINES

H. A. PEARSE
Metallurgical Consultant
Minerals Beneficiation and Extraction
of Non-Ferrous Metals
19 Pokahoe Dr., North Tarrytown, N. Y.
Phone ME 1-0810

LUCIUS PITKIN, INC.
Mineralogists
Assayers—Chemists—Spectroscopists
Shippers' Representatives
PITKIN BLDG., 47 FULTON ST., NEW YORK
Cable Address: Niktip

HARRY J. WOLF
Mining and Consulting Engineer
Examinations—Valuations—Management
3 Glenwood St., Little Neck 63, N. Y.
Cable: MINEWOLF Tel. HUnter 2-7843

DAVIDSON CHARLTON WYSOR
Geologist and Sales Engineer
Fifty Church St.
New York 7, N. Y. DIgby 9-3137

Ohio

B. B. R. DRILLING CO.
National Road West
St. Clairsville, Ohio
Diamond Core Drilling Contractors
Mineral Cores Guaranteed Foundation Testing

Pennsylvania

EAVENSON, AUCHMUTY & GREENWALD
MINING ENGINEERS
Mine Operation Consultants
Coal Property Valuations
2320 Koppers Bldg. Pittsburgh 19, Pa.

GRAFF ENGINEERING COMPANY
Mining Engineers and Surveyors
39 E. Campbell St. Blairsville, Pa.

ROBERT S. MAYO
Civil Engineer Lancaster, Pa.
Specializing in Concrete Lining of Tunnels, Haulageways and Shafts. Special Equipment for Subaqueous Construction.

J. B. MORROW
COAL CONSULTANT
Oliver Bldg. Pittsburgh, Pa.

PENNSYLVANIA DRILLING COMPANY
Subsurface Explorations. Grouting Industrial Water Supply. Mineral Prospecting Large Diameter Drilled Shafts.
Reports
1205 Chartiers Ave., Pittsburgh 20, Pa.

SPRAGUE & HENWOOD, Inc.
SCRANTON 2, PA.
Diamond Drill Contractors and Manufacturers
Core borings for testing mineral deposits in any part of the world.

J. W. WOOMER & ASSOCIATES
Consulting Mining Engineers
Modern Mining Systems and Designs
Foreign and Domestic Mining Reports
Henry W. Oliver Bldg., Pittsburgh, Pa.

Tennessee

JAMES A. BARR
Consulting Engineer
Mt. Pleasant, Tennessee

J. R. THOENEN
Consulting Mining Engineer
Sanford Day Road
Concord, Tennessee

Texas

GUY E. INGERSOLL
Registered Professional Engineer
in Texas, Arizona and New Mexico
Mine Examinations and Geological Reports
5505 Timberwolf Drive — El Paso, Texas

EXAMINATION–EVALUATION–EXPLORATION
METALLIC AND NONMETALLIC MINERALS
DOMESTIC–FOREIGN
HOWARD G. SCHOENIKE
Consulting Mining Geologist
4039 Turnberry Circle
MOhawk 5-7079 — Houston 25, Texas

CONRAD WARD THOMAS
Registered Professional Engineer
COMPLETE MINING CONSULTING U.S. & FOREIGN
Bank of the Southwest Bldg., Houston, Texas

Utah

BOOTH COMPANY, INC.
Metallurgical & Chemical Engineers
Research and Consulting
Complete Laboratory
Plant Operation and Testing
333 W. 14th So. St.
Salt Lake City 15, Utah

CENTENNIAL DEVELOPMENT CO.
Consulting Mining Engineers and Contractors
Shaft Sinking — Tunnel Driving
Mine Development
Eureka, Utah — **Phone 560**

FREDERICK W. HANSON
Mining Engineer
Registered Professional Engineer
Surveys—Examinations—Appraisals
Operations
32 So. 13th E., Salt Lake City 2, Utah

LOTTRIDGE-THOMAS & ASSOCIATES
Professional Engineers
705 Judge Building
SALT LAKE CITY 11, UTAH

PRODUCTION AND MANAGEMENT SPECIALIST
ROGER V. PIERCE
Underground Mining Methods, Cost Cutting Surveys—Production Analysis —Mine Mechanization—Mine Management.
808 Newhouse Bldg. EMPIRE 3-5373
Salt Lake City 4, Utah

SHENON AND FULL
Consulting Mining Geologists
1351 South 2200 East
Salt Lake City 8, Utah
Telephone HUnter 4-7251
Philip J. Shenon — **Roy P. Full**

INDUSTRIAL PLANT DESIGN
Process Development • Estimates
Economic Studies • Plant Layout
F.C. TORKELSON CO.
ENGINEERS
34 E. First South • Salt Lake City, Utah

Virginia

THOMPSON & LITTON
Consulting
CIVIL AND MINING ENGINEERS
P.O. Box 517 — Wise, Virginia
Surveys Examination Apraisals Design
Tel. Wise 6215

Washington

I. G. IRVING
Consulting Mining Geologist
Mine Examination and Valuation
Geological Investigations
Counsel in Development and Exploration
Financing of Prospects
ASSOCIATED WITH INVESTMENT EXCHANGE
706-735 Securities Building
Seattle, Washington Phone MAin 4-5416

Spokane, Wash. — Globe, Ariz.
DIAMOND CORE DRILL CONTRACTORS
Diamond Bits — Drilling Accessories
R. S. McCLINTOCK DIAMOND DRILL CO.

West Virginia

DIAMOND CORE DRILLING CONTRACTORS
Testing Mineral Deposits
Foundation Borings
MOTT CORE DRILLING CO.
Huntington, W. Va.

Canada

J. D. BATEMAN
Consulting Geologist
80 Richmond St. W.
Toronto 1, Canada — EMpire 4-3182

M. G. SMERCHANSKI
Consulting Mining Geologist
Registered Professional Engineer
411 Childs Bldg. Winnipeg, Manitoba.
Phone: Whitehall 2-6323

Mexico

WILLIAM J. SHEDWICK, JR.
Mine and Geologic Reports
Mexico and Latin America
New Jersey License 2744-a
P. De La Reforma 20-304 Mexico 1, D.F.

Southern Rhodesia

DAVID C. SHARPSTONE
MINING ENGINEER and GEOLOGIST
Bulawayo — So. Rhodesia
Private Bag : T 199 Cables : Minexams

Advertisers Index

ABCs Scale Div. McDowell Co., Inc. *Edward Howard & Co.* *

Allis-Chalmers Mfg. Co. Construction Machinery Div. *Bert S. Gittins Adv., Inc.* *

Allis-Chalmers Mfg. Co. Industrial Equipment Div. *Compton Adv. Inc.* 467, 469

American Brattice Cloth Corp. *Tri-State Adv., Co., Inc.* *

American Cyanamid Co. *James J. McMahon, Inc.* 472B, 472C

American Manganese Steel Div. American Brake Shoe Co. *Griswold-Eshleman Co.* *

American Mine Door Co. *Ray Sayre Adv.* *

American Steel Foundries *Erwin Wasey, Ruthrauff & Ryan, Inc.* *

Anaconda Co., The *Kenyon & Eckhardt, Inc.* *

ASEA Electric Co. *Mann-Ellis, Inc.* 487

Atlas Copco *John Mather Lupton Co. Inc.* *

Bixby-Zimmer Engineering Co. *Arbingast, Becht and Assoc., Inc.* 550

Boyles Bros. Drilling Co. *W. S. Adamson & Assoc.* 555

Brown Inc., David *The McCarty Co.* *

Brunner & Lay, Inc. *Norman P. Hewitt Adv.* *

Bucyrus-Erie Co. *Bert S. Gittins Adv.* *

Card Iron Works, C. S. *Mosher-Reimer & Williamson Adv.* *

Carrier Conveyor Corp. *Doe-Anderson Adv.* *

Caterpillar Tractor Co. *N. W. Ayer & Sons, Inc.* 494, 495

Clarkson Co. *Norton M. Jacobs Adv.* *

Colorado Fuel & Iron Corp., The *Doyle, Kitchen & McCormick, Inc.* 481

Deister Concentrator Co., Inc. *Louis B. Wade, Inc.* 554

Denver Equipment Co. *Galen E. Broyles Co., Inc.* *

Differential Steel Car Co. *Coleman Todd & Assoc.* *

Dorr-Oliver Inc. *G. M. Basford Co.* 474, 475

Dwight-Lloyd Div. McDowell Co., Inc. *Edward Howard & Co.* *

Eimco Corp., The *Matsie Co.* 491

Ellicott Machine Corp. *O. S. Tyson and Co., Inc.* *

Equipment Engineers, Inc. *Norton M. Jacobs Adv.* 472D

Ferro Corp., Porcelain Div. *Downing Industrial Adv., Inc.* 552

Ford Motor Co. *J. Walter Thompson, Inc.* 482, 483

Gallagher Co., The *W. S. Adamson & Assoc.* 541

Gardner-Denver Co. *The Buchen Co.* Third Cover

Gruendler Crusher & Pulverizer Co. *Christy Humburg Adv.* 545

Hardinge Co., Inc. *Adams Associates, Inc.* 549

Hawthorne Inc., Herb J. *Darwin H. Clark Co.* *

Hercules Powder Co. (Explosives) *Fuller & Smith & Ross, Inc.* *

Humphreys Engineering Co. *Ed M. Hunter & Co.* *

Infilco Inc. *Willard G. Gregory & Co.* *

Ingersoll-Rand Co. *Beaumont, Heller & Sperling, Inc. Marsteller, Rickard, Gebhardt & Reed Inc.* *

International Harvester Co. *Aubrey, Finlay, Marley, & Hodgson, Inc.* 496A, 496B, 496C, 496D

International Nickel Co., The *Marschalk & Pratt* 484

Jeffrey Mfg. Co. *The Griswold-Eshleman Co.* *

Joy Mfg. Co. *W. S. Walker Adv. Inc.* 472A

Kennedy Van Saun Mfg. & Engrg. Corp. *Robert S. Kampmann Jr.* 473

KW-Dart Truck Co. *Carl Lawson Adv.* *

Longyear Co., E. J. *Pidgeon Savage & Lewis, Inc.* *

Mace Co. *

Machinery Center Inc. *W. S. Adamson and Assoc.* *

Magor Car Corp. *Bauer Advertising* *

Mayo Tunnel & Mine Equipment *The Godfrey Agency* *

Michigan Chemical Corp. *Wesley Aves & Associates* *

Mine & Smelter Supply Co. *Walter L. Schump, Adv.* 492

Mine Safety Appliances Co. *Ketchum, MacLeod & Grove, Inc.* Fourth Cover

Nagle Pumps, Inc. *Tri-State Adv. Co., Inc.* *

National Iron Co. *H. E. Westmoreland, Inc.* 540

National Malleable & Steel Castings Co. *Palm & Patterson Inc.* 542

Naylor Pipe Co. *Fred H. Ebersold, Inc.* *

Nordberg Mfg. Co. *Russell T. Gray, Inc.* 480

Northern Blower Co. *Carr Liggett Adv., Inc.* *

Oldsmobile Div. General Motors Corp. *D. P. Brother & Co.* 466

Phelps Dodge Refining Corp. *The House of J. Hayden Twiss, Inc.* *

Sanford-Day Iron Works, Inc. *Charles S. Kane Co.* 470, 471

Sheffield Div. ARMCO Steel Corp. *Potts · Woodbury, Inc.* 472

Smidth & Co., F. L. *The Stuart Co.* *

Spencer Chemical Co. *Bruce B. Brewer & Co.* *

Sprague & Henwood, Inc. *Anthracite Adv.* *

Stanco Mfg. & Sales Inc. *NKR Advertising, Inc.* *

Stearns-Roger Mfg. Co. *Mosher-Reimer-Williamson Adv. Agency, Inc.* *

Syntron Co. *Servad, Inc.* 551

Texas Gulf Sulphur Co. *Sanger-Funnell, Inc.* 536A

Traylor Engrg. & Mfg. Co. *Ritter-Lieberman, Inc.* 488

Tyler Co., W. S. 553

Vulcan Iron Works *Mosher-Reimer & Williamson Adv.* *

Western-Knapp Engineering Co. *Westcott-Frye & Assoc.* *

Western Machinery Co. *Westcott-Frye & Assoc.* *

Wheel Trueing Tool Co. *Clark & Bobertz, Inc.* 544

Wilfley & Sons, Inc., A. R. *Ed M. Hunter & Co.* Second Cover

Wilkinson Process Rubber Co., Ltd., The *Greenlys Ltd.* 538

Windeler Co., Ltd., George *Geo. E. S. Thompson Adv.* *

* Previous Issues

CHECK THIS GARDNER-DENVER LINE-UP BEFORE YOU BUILD OR BUY YOUR NEXT JUMBO

1 REMOTE CONTROLS . . . all controls, both hydraulic and pneumatic, can be arranged for handling all operations from a centralized location —the most convenient location for your drilling operation.

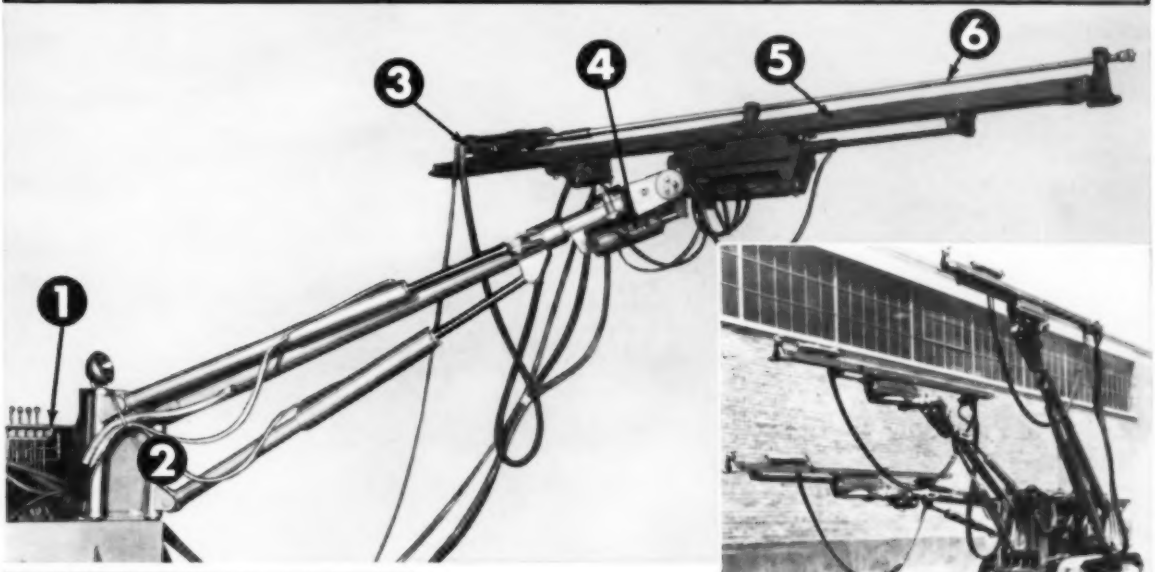
2 BOOMS . . . hydraulic, creep-free booms—straight, offset or tripod types. A choice of hand or automatic hydraulic pump. Lengths to suit your drilling needs.

3 DRIFTERS . . . seven hard-hitting, fast-acting models—the most complete line of time-tested drifter drills available. Sizes from 2¾" to 5½" cylinder bore.

4 DRILL POSITIONER . . . DPU hydraulic drill positioner—120° swing (60° from center to center), 90° dump (30° up, 60° down)—can be indexed for roof pinning or down hole drilling.

5 FEEDS . . . aluminum alloy screw feeds take steel changes up to 12′. New channel screw feed mountings permit changes up to 14′. Lightweight and heavy-duty chain feeds for changes to 20′. All can be remote-controlled.

6 DRILL STEEL . . . most complete line of sectional carburized drill steel (five series from ⅞" hex. to 1⅞" hex.) in lengths from 2′ to 20′. Carburized to resist abrasion longer and increase compressive strength. Also carburized made-up steel in a variety of sizes, shanks and lengths.



THIS HARD HAT
MEANS BETTER DRILLING

Gardner-Denver men and mining engineers have worked hand in hand for many years. This teamwork has resulted in a safe, hard-hitting line of drilling equipment for use in every type of rock and ore. At Gardner-Denver there's no substitute for men —our philosophy of growth for 100 years.

GARDNER-DENVER Since 1859

1959 YEARS

Here's the most complete and versatile line of coordinated drills, feeds, booms and controls available anywhere. Save time and manpower. Drill faster. Hold line cuts in line. Or use big bore burn cut for pulling deeper rounds. Handle high-face room and pillar mining with ease. See your Gardner-Denver jumbo specialist. He can help you plan a job-built, custom-engineered jumbo using your own truck or tractor . . . or deliver a complete Gardner-Denver crawler-, wheel- or rail-mounted jumbo.

EQUIPMENT TODAY FOR THE CHALLENGE OF TOMORROW

GARDNER-DENVER

Gardner-Denver Company, Quincy, Illinois
Export Division: 233 Broadway, New York 7, New York
In Canada: Gardner-Denver Company (Canada), Ltd., 14 Curity Avenue, Toronto 16, Ontario

"IN CASE OF EMERGENCY"

Mine emergencies happen without warning . . . and when they do happen, equipment that carries the "in case of emergency" label suddenly becomes vital to fire fighting and rescue efforts. Breathing protection devices are a major part of emergency mine equipment.

Below is a check list of this equipment offered by MSA. If you would like to make sure your emergency program is up-to-date, why not have our representative check your requirements and suggest a regular inspection and maintenance schedule.

M-S-A McCAA® Oxygen Breathing Apparatus—
gives complete breathing protection in any unbreathable atmosphere for a minimum of two hours. Used under the hardest physical conditions . . . in fighting and sealing fires, re-establishing ventilation, and rescue operations. U. S. Bureau of Mines approved.

M-S-A Chemox®—
allows complete breathing protection in any gaseous or oxygen deficient area for a minimum of 45 minutes. Generates its own oxygen supply from replaceable canister. Weighs only 13½ lbs. U. S. Bureau of Mines approved.

M-S-A All-Service Mask®—
assures safe, comfortable breathing protection against smoke and toxic gases including carbon monoxide—singly—or in combination where there is sufficient oxygen to sustain life. U. S. Bureau of Mines approved.

M-S-A Self-Rescuer®—
a miniature mask for use in deadly carbon monoxide following fire or explosion. Gives the miner precious minutes of emergency breathing protection. Unit is compact, lightweight; may be stored in quantity underground or carried individually. U. S. Bureau of Mines approved.

M-S-A Air and O_2 Mask—
designed for 30 minutes maximum breathing protection in any atmosphere—supplies air or oxygen in exact accordance with breathing requirements. Flow ceases during exhalation for added economy. Comfortable to wear and easy to use.

M-S-A Pneolator®—
provides automatic artificial respiration that assures maximum chances of recovery for victims of poisonous gases, electrical shock, heart attacks, or other causes of asphyxia. Housed in compact, lightweight glass fiber case.

MSA®
SAFETY EQUIPMENT HEADQUARTERS

MINE SAFETY APPLIANCES COMPANY
201 North Braddock Avenue, Pittsburgh 8, Pa.
MINE SAFETY APPLIANCES CO. OF CANADA, LTD.
Toronto, Montreal, Calgary, Edmonton, Winnipeg, Vancouver, Sydney, N. S.
MINE SAFETY APPLIANCES CO. de MEXICO, S.A. de C.V.
Mexico 4, D. F., Mexico